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DELFIC Fallout Prediction Code Radiation Physics Package Upgrade

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13. ABSTRACT *(Maximum 200 words)*

The DEfense Land Fallout Interpretive Code (DELFIC) is the Defense Nuclear Agency standard phenomenology code for computing fallout environments from nuclear weapons detonations. This report describes the results of a program to update the DELFIC radiation physics package, that portion of the code which calculates the radioactive decay of initial fission product inventories and their contribution to radiation exposure rate. Updates include corrections to errors in following multi-path decay chains, the inclusion of ENDF/B-6 decay constant data and the expansion of the number of radionuclides which contribute to direct exposure to irradiation from surface contamination.

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CONVERSION TABLE

Conversion Factors for U.S. Customary to Metric (SI) Units of Measurement

MULTIPLY → TO GET	BY	← TO GET DIVIDE
angstrom	1.000 000 X E-10	meters (m)
atmosphere (normal)	1.013 25 X E +2	kilo pascal (kPa)
bar	1.000 000 X E +2	kilo pascal (kPa)
barn	1.000 000 X E -28	meter ^{2} (m^2)
British thermal unit (thermochemical)	1.054 350 X E +3	joule (J)
calorie (thermochemical)	4.184 000	joule (J)
cal (thermochemical)/cm^2	4.184 000 X E -2	mega joule/m^2 (MJ/m^2)
curie	3.700 000 X E +1	giga becquerel (GBq)*
degree (angle)	1.745 329 X E -2	radian (rad)
degree Fahrenheit	$t_k = (t^oF+459.67)/1.8$	degree kelvin (K)
electron volt	1.602 19 X E -19	joule (J)
erg	1.000 000 X E -7	joule (J)
erg/second	1.000 000 X E -7	watt (W)
foot	3.048 000 X E -1	meter (m)
foot-pound-force	1.355 8818	joule (J)
gallon (U.S. liquid)	3.785 412 X E -3	meter^3 (m^3)
inch	2.540 000 X E -2	meter (m)
jerk	1.000 000 X E +9	joule (J)
joule/kilogram (J/kg) (radiation dose absorbed)	1.000 000	Gray (Gy)
kilotons	4.183	terajoules
kip (1000 lbf)	4.448 222 X E +3	newton (N)
kip/inch^2 (ksi)	6.894 757 X E +3	kilo pascal (kPa)
ktap	1.000 000 X E +2	newton-second/m^2 ($N-s/m^2$)
micron	1.000 000 X E -6	meter (m)
mil	2.540 000 X E -5	meter (m)
mile (international)	1.609 344 X E +3	meter (m)
ounce	2.834 952 X E -2	kilogram (kg)
pound-force (lbs avoirdupois)	4.448 222	newton (N)
pound-force inch	1.129 848 X E -1	newton-meter (N - m)
pound-force/inch	1.751 268 X E +2	newton/meter (N/m)
pound-force/foot^2	4.788 026 X E -2	kilo pascal (kPa)
pound-force/inch^2(psi)	6.894 757	kilo pascal (kPa)
pound-mass (lbm avoirdupois)	4.535 924 X E -1	kilogram (kg)
pound-mass-foot^2 (moment of inertia)	4.214 011 X E -2	kilogram-meter^2 ($kg \cdot m^2$)
pound-mass-foot^3	1.601 846 X E +1	kilogram/meter^3 (kg/m^3)
rad (radiation dose absorbed)	1.000 000 X E -2	Gray (Gy)**
roentgen	2.579 760 X E -4	coulomb/kilogram (C/kg)
shake	1.000 000 X E -8	second (s)
slug	1.459 390 X E +1	kilogram (kg)
torr (mmHg, 0°C)	1.333 22 X E -1	kilo pascal (kPa)

* The becquerel (Bq) is the SI unit of radioactivity; 1 Bq = 1 event/s.
** The Gray (Gy) is the SI unit of absorbed radiation.

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TABLES (Continued)

SECTION 1
INTRODUCTION

The DEfense Land Fallout Interpretive Code (DELFIC) (Ref. 1) is the Defense Nuclear Agency standard phenomenology code for computing fallout environments from nuclear weapons detonations. Such environments include spatial and temporal distributions of radioactive fission products, activation products, unreacted bomb debris and their associated radiation exposure rates. A large number of available fallout and special applications codes are calibrated to DELFIC data or actually include portions of DELFIC in their construction. These codes include NewFALL (Ref. 2), DNAF1 (Ref. 3), SEER (Ref. 4), CIVIC (Ref. 5), FAS (Ref. 6). An alternative fallout code, WSEG-10 (Ref. 7), was developed before DELFIC, based on empirical data. Thus, neither it or its progeny share a specific development heritage with DELFIC. However, both have been influenced by the same limited amount of test observations.

DELFIC describes the rise of the fireball in the time frame of seconds and later, the formation of the cloud stem and, ultimately the formation of the stabilized radioactive cloud. It computes the fractionation of the fission products, i.e., their association with various particle sizes, depending on their volatility, and finally, it calculates the deposition of radioactivity on the ground, based on the same particle size considerations.

Basic to the DELFIC model is the radiation physics package, which calculates the isotopic inventory of radioactive nuclides as a function of time after burst. This inventory is important to fractionation analysis and determines the exposure to radiation emissions. In this report DELFIC is either referred to as "Original" DELFIC, meaning the current code before modification, or "Upgrade" DELFIC, meaning the code as modified by work performed during this study. Original DELFIC follows the decay of a large inventory of isotopes, but has gamma ray emission data for only a small fraction. Thus, its calculation of exposure to gamma emissions from fallout is incomplete. In addition the decay and branching constants and initial fission product inventories have not been revised in over 20 years. Finally, it has been observed that the code does not treat properly the decay of some portions of that inventory.

This report describes an effort to rectify as many of these problems as possible within the constraints of available resources. Thus, it contains explanations of problems associated with the logic of radioactive decay as treated in DELFIC and the steps taken to solve these problems. It also describes efforts to upgrade nuclear data in the code, particularly decay constants and the exposure rate multipliers associated with gamma ray emission rates.

SECTION 2
DECAY CHAIN LOGIC UPGRADE

DELFIC treatment of radioactive decay is limited to beta decay, beta-neutron decay and isomeric transition (IT). DELFIC handles radioactive decay by arranging its inventory in chains of increasing atomic number, which follow the decay process from the parent isotope through a number of daughter products and until a stable daughter is produced. Chains in which the decay process is limited to beta emission and IT are characterized by a single atomic mass number. Chains which include beta-neutron decay include isotopes having more than one atomic mass number. The code contains 118 such chains, including 692 isotopes, of which 118 are stable. A listing of the isotopes in the DELFIC library, arranged by chain, may be found in Appendix A of this report.

2.1 CONSERVATION OF INVENTORY IN A SINGLE, BRANCHING CHAIN

As originally written, the DELFIC decay scheme has problems conserving inventory. One instance of this problem occurs when DELFIC encounters a branch in a decay chain. An example of such a branching chain is shown in Figure 2-1. The compartments represent isotopes. The balloons represent the rate of transfer by radioactive decay from one compartment to the next, which is controlled by the "dcon," i.e., the decay constant. In the middle of the chain As83 may decay to either Se83m (Probability = 0.44) or Se83 and Se83m may undergo isomeric transition to Se83 (Prob. = 0.1) or it can undergo beta decay to reach Br83. The probabilities governing the decay path are referred to as branching ratios.

DELFIC handles the problem of branching by computing the decay for this chain separately for monolithic subsets of the chain, each accounting for a single branch, and adding the results. In order to avoid miscounting the contribution of initial inventory nuclides (nuclides which exist at zero time) in this process, DELFIC multiplies the abundance of each by the product of all subsequent branching ratios in the subset. In this way DELFIC partitions a portion of initial inventory for use in each subset of the chain and so conserves that inventory. Further, according to DELFIC logic, all isotopes which occur subsequent to a branch are not affected by it and therefore contribute 100% of their inventory to the subset.

In the case of the chain depicted in Figure 2-1, the resulting three monolithic subset chains and the associated initial inventory partitions are given in Table 2-1. The first subset includes the path through Se83m and Se83, the second through Se83 alone, and the third through Se83m alone. It can be seen from Table 2-1 that the DELFIC logic works well until after the first branch occurs. Up to that point the sum of the inventory partitions for each isotope over all subsets is unity, as shown in the last column of the table. After the first branch occurs, however, the logic goes

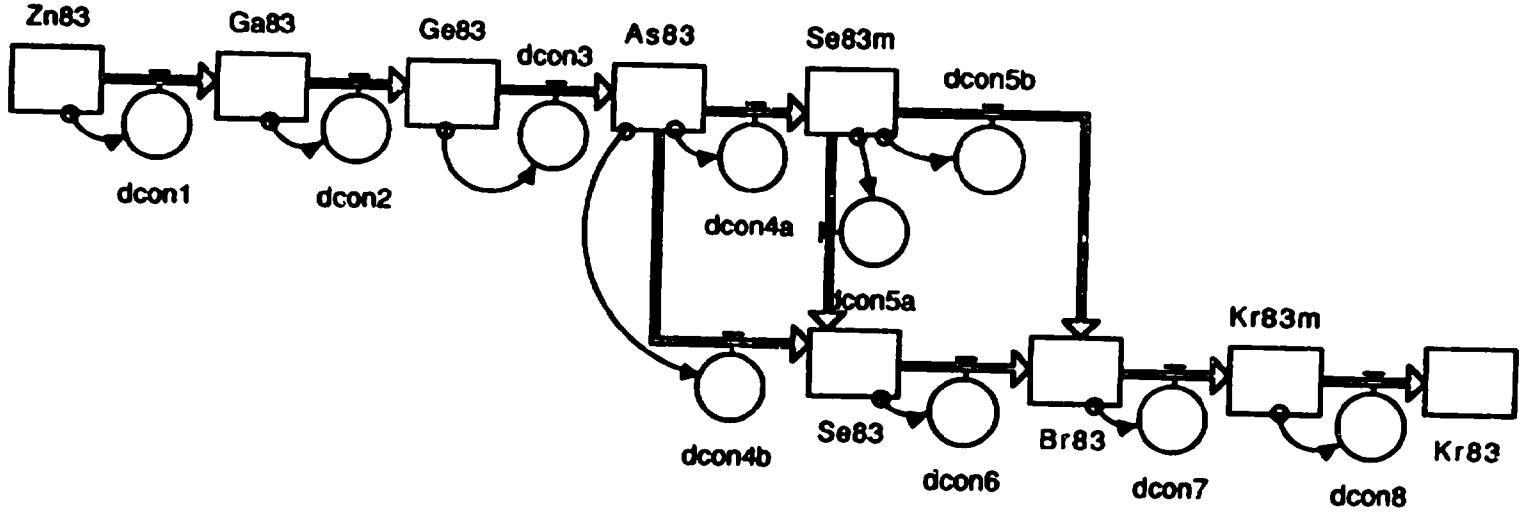

Figure 2-1. DELFIC decay chain for mass number 83 with three branches.

Table 2-1. Original DELFIC inventory partitions for subsets of decay chain, mass number 83.

Isotope	Chain 1	Chain 2	Chain 3	Total
Zn83	0.044	0.396	0.56	1
Ga83	0.044	0.396	0.56	1
Ge83	0.044	0.396	0.56	1
As83	0.044	0.396	0.56	1
Se83m	0.1	0.9	0	1
Se83	1	0	1	2
Br83	1	1	1	3
Kr83m	1	1	1	3

Table 2-2. Upgrade DELFIC inventory partitions for subsets of decay chain, mass number 83.

Isotope	Chain 1	Chain 2	Chain 3	Total
Zn83	0.044	0.396	0.56	1
Ga83	0.044	0.396	0.56	1
Ge83	0.044	0.396	0.56	1
As83	0.044	0.396	0.56	1
Se83m	0.1	0.9	0	1
Se83	0.5	0	0.5	1
Br83	0.333	0.333	0.333	1
Kr83m	0.333	0.333	0.333	1

awry, in that each subset includes 100% of the initial inventory of all isotopes subsequent to the branch. In the case of the chain depicted in Figure 2-1, this results in the initial inventory of Se83 being counted twice and those of Br83 and Kr83m being counted three times.

The existence of the initial inventory conservation problem in branching chains arises because the code treats each subset of the chain serially, never assembling the probability array given in Table 2-1. The upgrade of DELFIC solves the problem by proceeding through the creation of branching chain subsets twice, once to assemble the partitioning array and re-normalize its values, as shown in Table 2-2, and a second time to actually calculate the decay and total isotopic abundance. Note that the decay of initial inventory below the branch is the same for every subset of the chain. Therefore, the initial distribution of that inventory between the subsets is not important, so long as the total is conserved.

Table 2-3. Comparison of original and update DELFIC activity calculation for chain of mass number 83.

Isotope:	Zn83	Ga83	Ge83	As83	Se83m	Se83	Br83	Kr83m
Original DELFIC								
Total Inventory (Atoms/10^4 Fissions):								
Time = 0	1.500E-03	1.475E+00	1.325E+01	2.350E+01	4.750E+00	3.148E+00	2.250E-01	0.000E+00
Subset One Inventory (Atoms/10^4 Fissions):								
T = 0	6.600E-05	6.490E-02	5.830E-01	1.034E+00	4.750E-01	3.148E+00	2.250E-01	0.000E+00
T = 8.02 sec	0.000E+00	0.000E+00	4.005E-02	8.210E-01	1.225E+00	3.207E+00	2.366E-01	1.484E-04
Subset Two Inventory (Atoms/10^4 Fissions):								
T = 0	5.940E-04	5.841E-01	5.247E+00	9.306E+00	4.275E+00		2.250E-01	0.000E+00
T = 8.02 sec	0.000E+00	0.000E+00	3.604E-01	7.389E+00	1.103E+01		8.587E-01	3.185E-04
Subset Isocon Inventory (Atoms/10^4 Fissions):								
T = 0	8.400E-04	8.260E-01	7.420E+00	1.316E+01		3.148E+00	2.250E-01	0.000E+00
T = 8.02 sec	0.000E+00	0.000E+00	5.097E-01	1.045E+01		1.356E+01	2.567E-01	1.528E-04
Original DELFIC								
Total Inventory (Atoms/10^4 Fissions):								
T = 8.02 sec	0.000E+00	0.000E+00	9.102E-01	1.866E+01	1.226E+01	1.677E+01	1.352E+00	6.197E-04
Upgrade DELFIC								
Subset One Inventory (Atoms/10^4 Fissions):								
T = 0	6.600E-05	6.490E-02	5.830E-01	1.034E+00	4.750E-01	1.574E+00	7.500E-02	0.000E+00
Subset Two Inventory (Atoms/10^4 Fissions):								
T = 0	5.940E-04	5.841E-01	5.247E+00	9.306E+00	4.275E+00		7.500E-02	0.000E+00
Subset Three Inventory (Atoms/10^4 Fissions):								
T = 0	8.400E-04	8.300E-01	7.420E+00	1.316E+01		1.574E+00	7.500E-02	0.000E+00
Upgrade DELFIC								
Total Inventory (Atoms/10^4 Fissions):								
T = 8.02 sec	0.000E+00	0.000E+00	9.101E-01	1.866E+01	1.225E+01	1.363E+01	8.907E-01	3.267E-04
Differences	No Change	No Change	No Change	No Change	No Change	-18.71%	-34.12%	-47.28%

a. Difference: (Upgrade-Original)/Original * 100%

Using the chain shown in Figure 2-1 as an example, the impact of the upgrade correction is illustrated in Table 2-3 for the chain applicable to mass number 83. In this case the difference between activity of an individual isotope located below the branch, as calculated by original and update DELFIC, is significant, with the upgrade providing activities which are 20% to 50% less than those calculated with the original code.

2.2 CONSERVATION OF INVENTORY IN MULTIPLE, BRANCHING CHAINS

A beta-neutron decay results in a daughter isotope which has a different atomic number than the parent and is therefore also likely to have a beta decay parent. Thus, a branch of a decay chain may be held in common by two chains. In DELFIC this situation can become quite complicated, as shown in Figure 2-2, which is a simplified depiction of the relationship between two chains, initially of mass numbers 89 and 90, which couple at Kr89.

The coupled chains depicted in Figure 2-2 produced an initial inventory conservation problem similar to that described in 2.1 for branching chains. DELFIC assembles a set of monolithic chains

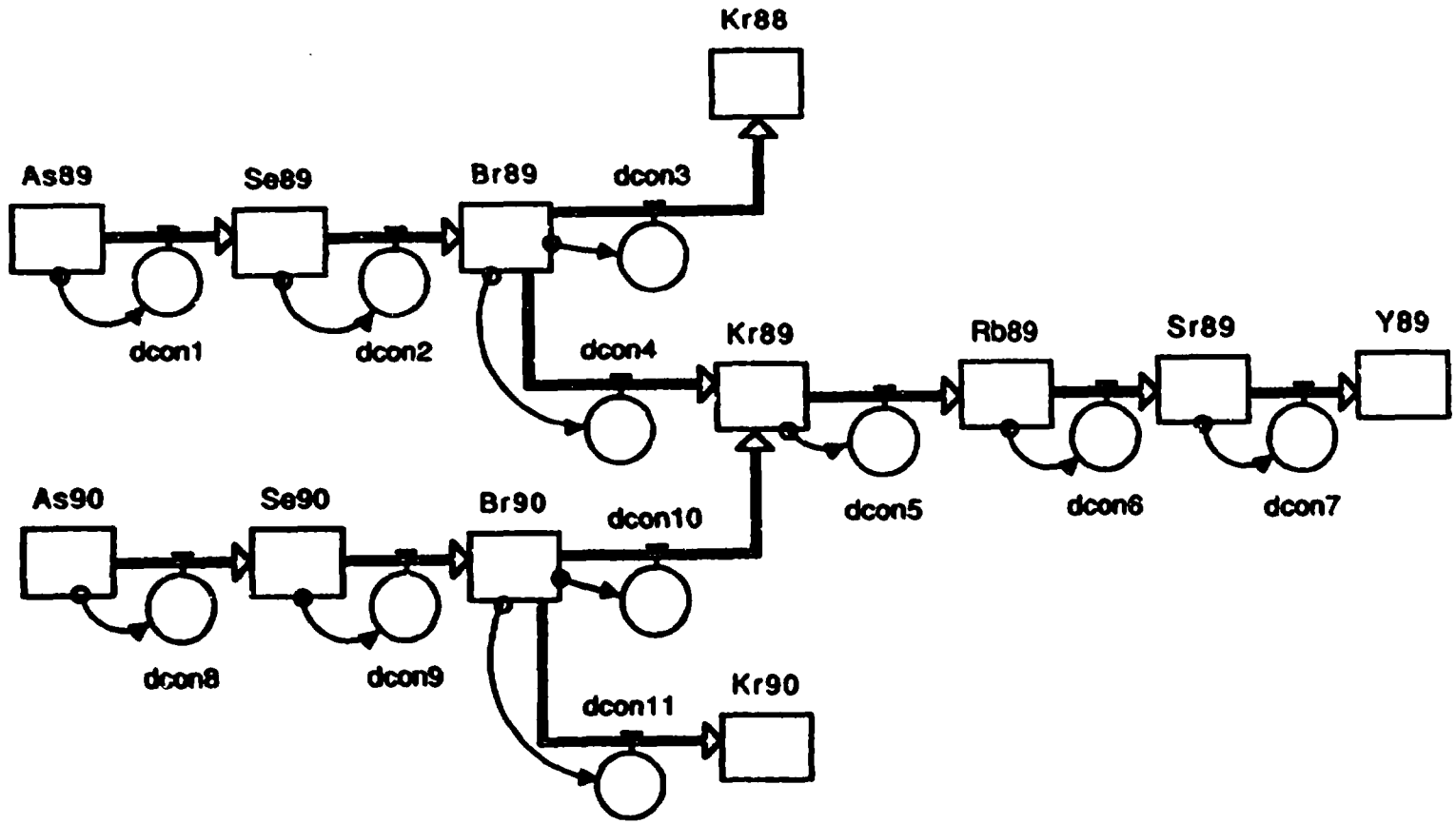

Figure 2-2. Coupled chains sharing branches.

which represent the branching chain. In doing so the code includes nuclides which have been included in another decay calculation. As originally configured, DELFIC also includes the initial inventory of all members of each monolithic chain in the new decay calculation. Thus, the initial inventories of isotopes are added to the calculation as many times as the isotopes are found within a chain.

The problem of inventory conservation in multiple, branching chains is solved in upgrade DELFIC by the simple expediency of setting the initial inventory value to zero after it has been used once. Thus, inclusion of an isotope subsequent to its initial appearance in a decay chain adds only the inventory attributable to decay. This solution is illustrated in Table 2-4, which depicts mass number chain 89 and that portion of the same chain proceeding from the chain of mass number 90, decayed to 8.02 sec. In the lines of data which represent the original DELFIC treatment of these two chains, it can be seen that the initial inventory is being counted twice, once in the 89 chain and again in the 90 chain. Upgrade DELFIC zeros out the inventories of the isotopes common to both chains in the second pass through them. The effect

Table 2-4. Comparison of original and update DELFIC activity calculation for coupled chains, mass number 89 and 90.

Initial Inventory Conservation in Decay Chains with Common Branches

Isotope:	As89	Se89	Br89	Kr89	Rb89	Sr89	Y89
Original DELFIC							
Total Inventory (Atoms/10^6 fissions):							
T = 0	1.528E+00	4.824E+01	1.233E+02	4.060E+01	6.300E+00	9.500E-03	0.000E+00
Subset One Inventory (Atoms/10^6 fissions):							
T = 0	1.528E+00	4.824E+01	1.233E+02	4.060E+01	6.300E+00	9.500E-03	0.000E+00
T = 8.02 sec	0.000E+00	3.064E+00	5.477E+01	1.394E+02	9.066E+00	5.427E-02	3.883E-08
Subset Two Inventory (Atoms/10^6 fissions):							
T = 0				4.060E+01	6.300E+00	9.500E-03	0.000E+00
T = 8.02 sec				6.034E+01	7.870E+00	5.188E-02	3.808E-08
Original DELFIC							
Total Inventory (Atoms/10^6 fissions):							
T = 8.02 sec	0.000E+00	3.064E+00	5.477E+01	1.998E+02	1.694E+01	1.062E-01	7.691E-08
Upgrade DELFIC							
Subset One Inventory (Atoms/10^6 fissions):							
T = 0	1.528E+00	4.824E+01	1.233E+02	4.060E+01	6.300E+00	9.500E-03	0.000E+00
Subset Two Inventory (Atoms/10^6 fissions):							
T = 0				0.000E+00	0.000E+00	0.000E+00	0.000E+00
Upgrade DELFIC							
Total Inventory (Atoms/10^6 fissions):							
T = 8.02 sec	0.000E+00	3.064E+00	5.477E+01	1.603E+02	9.519E+00	5.538E-02	3.923E-08
Difference[a]:	No Change	No Change	No Change	-19.73%	-43.79%	-47.83%	-48.99%

a. Difference: (Upgrade-Original)/Original * 100%

of this change on the chains portrayed in Table 2-4 is to reduce the decayed inventory of some isotopes by as much as 50%.

2.3 ALTERNATIVE DECAY MODES

At this time nothing has been done to include additional decay modes, such as positron emission or electron capture, in the DELFIC decay scheme. Such inclusion is necessary in order to increase the number of nuclides treated by the code. Ultimately, this must be done in order for DELFIC correctly calculate early time activity.

SECTION 3
DATA BASE UPGRADE

DELFIC contains data for 692 nuclides, having atomic numbers between 27 and 66. These nuclides are accounted for in decay chains, as described previously in Section 2, in which the decay is followed from an initial radioactive isotope, which is the product of fission or activation, to the final, stable element in the chain.

The data required by DELFIC to calculate the population of radioactive isotopes and their associated contribution to exposure rates from surface contamination, i.e., fallout, include the following:

Initial Abundance
Radioactive Decay Constants
Branching Ratios
Exposure Rate Multipliers

This program of DELFIC data base review and upgrade occurred as the Evaluated Nuclear Data File (ENDF) (Ref. 8) was being updated from version 5 to version 6. Initial availability of ENDF/B-6 was limited to decay constants and gamma ray emission spectra. Therefore, this report describes the revision of DELFIC to include new decay constant data and new exposure rate multipliers, calculated using ENDF/B-6 gamma ray emission data.

3.1 RADIOACTIVE DECAY CONSTANTS

DELFIC contains a library of 692 fission products of which 118 are the stable ends of decay chains. Therefore, 574 decay constants were replaced with new values taken from ENDF/B-6. In addition to the data required to update the existing DELFIC library, ENDF/B-6 offers decay constants for an additional 171 radionuclides. New decay chains would have to be added to DELFIC in order to accommodate the remaining data.

The mean difference between new and old decay constants is +72 ± 593%. Thus, it can be seen that, while there is little net change in the decay constants overall, there is tremendous variance in the value of individual differences. The original and upgrade decay constants are listed in Appendix A.

Tables 3-1 through 3-8 give the most important 32 isotopes from the standpoint of surface exposure ($R/hr/KT/m^2$) one hour after U235, U238 and Pu239 fast fission and U238 thermonuclear fission. Part of the reason for the difference between the original and upgrade lists for each fissile isotope is the decay constant revision. The total activity listed at the bottom of the isotope inventory column represents 100% of the activity and is not simply a sum of column values. The difference in total activity is

partially due to decay constant changes. However, it is also due to changes in the handling of initial inventory, as described in Section 2. The separate impact of each change can be inferred from the following values for total activity one hour after U238 thermonuclear fission:

Original DELFIC: $4.391*10^8$ Ci/KT

Upgrade DELFIC (Partial): $4.264*10^8$ Ci/KT
Revised Initial Inventory Conservation Only

Upgrade DELFIC (Complete): $4.326*10^8$ Ci/KT
Revised Initial Inventory Conservation
Revised Decay Constants

The effect of revising the treatment of initial inventory conservation is to reduce the total activity by a few percent. The net effect of the decay constant changes is to increase the activity, which is consistent with the longer mean value for the revised decay constants.

3.2 EXPOSURE RATE MULTIPLIERS

DELFIC translates ground surface-deposited activity into exposure rate by means of Exposure Rate Multipliers (ERM). The dimensions of the ERM library used in DELFIC are

$$(R/Hr)/(Disintegrations/Sec\text{-}cm^2)$$

The original DELFIC contains ERM values for 181 isotopes. In upgrade DELFIC the number has been expanded to 574, i.e., all the radioactive elements in the DELFIC library.

Expansion of the DELFIC ERM data base required that new ERM's be calculated. This was accomplished using gamma ray source rates and one-dimensional radiation transport methodology to obtain the exposure rate one meter above a flat plane due to gamma emissions on the surface of that plane. The gamma ray source rates were obtained from the emission spectra (per disintegration) for individual fission product isotopes contained in ENDF/B-6. The one-dimensional transport code used in the calculation was ANISN (Ref. 9), which solves the boltzmann equation in one dimension with anisotropic scattering.

The ANISN calculation was performed in the adjoint mode to determine the importance of isotropic gamma ray emissions of all energies and all locations in producing gamma ray tissue kerma (rad(tis)) one meter above the ground surface. The calculations were performed using cross sections from the PVC 36 energy group library (Ref. 10) using an S_{40} quadrature and a P_5 legendre scattering order. The ground and air constituents used in the

calculations are given in Table 3-9. Tissue kerma was converted to roentgens (R) by dividing tissue kerma by 0.957.

The results of the ANISN calculations for a source location on the surface of the ground (actually 0.25 cm above the surface) are given in Table 3-10 and depicted graphically in Figure 3-1. The energy boundary format of the data shown is changed somewhat from that originally calculated to make it consistent with the format of the available source spectra data. These data were multiplied by the gamma rays per energy group per disintegration from ENDF/B-6 for each DELFIC radioactive isotope to obtain the new ERM library.

Note that the ERM values in DELFIC do not include the effect of attenuation due to ground roughness. Ground is not smooth on the scale of fallout particles, which range in size from microns to hundreds of microns. Rather it is made up of granules having interstitial crevices, having sizes of the same order as the fallout particles. The tendency for fallout particles to deposit in these crevices results in the attenuation of emitted radiation. The effect of ground surface roughness typical of a smooth dirt field is to reduce gamma ray exposure rates by approximately 30% (Ref. 11).

Appendix A contains a listing of ERM values for the original and upgrade DELFIC libraries. Appendix B provides ERM values for an additional 171 radionuclides included in ENDF/B-6 but not treated by DELFIC. Comparing upgrade ERM values with those of the 181 elements in original DELFIC, the difference between the new and old is +29 ± 131%, i.e., the new values are slightly larger, while the variation for individual isotopes is substantial. Tables 3-1 through 3-8 give the most important 32 isotopes from the standpoint of surface exposure ($R/hr/KT/m^2$) one hour after U235, U238 and Pu239 fast fission and U238 thermonuclear fission. The tables also provide values for original and upgrade ERM's for the listed isotopes.

Table 3-1. Original DELFIC, U235 fast fission at 1 hr, 32 most important isotopes for surface exposure.

nuclide	Ci/KT	DCON[a]	ERM[b]	R/hr/KT/m^2	% of total R	Cumulative
55-cs-138	3.104E+07	3.588E-04	9.790E-06	1.124E+09	14.16%	14.16%
53-i-134	2.022E+07	2.180E-04	1.220E-05	9.127E+08	11.50%	25.66%
52-te-133m	1.259E+07	2.310E-04	1.120E-05	5.217E+08	6.57%	32.23%
57-la-142	1.989E+07	1.375E-04	6.010E-06	4.423E+08	5.57%	37.80%
59-pr-146	1.777E+07	4.735E-04	6.530E-06	4.293E+08	5.41%	43.21%
37-rb-89	1.021E+07	7.502E-04	1.100E-05	4.155E+08	5.23%	48.45%
52-te-134	1.619E+07	2.751E-04	6.840E-06	4.097E+08	5.16%	53.61%
42-mo-101	1.115E+07	7.913E-04	7.920E-06	3.267E+08	4.12%	57.72%
53-i-135	5.604E+06	2.874E-05	1.560E-05	3.235E+08	4.07%	61.80%
57-la-143	1.299E+07	6.418E-04	5.740E-06	2.759E+08	3.48%	65.27%
38-sr-92	1.237E+07	7.131E-05	5.880E-06	2.691E+08	3.39%	68.66%
39-y-94	1.839E+07	5.776E-04	3.480E-06	2.368E+08	2.98%	71.65%
43-tc-101	3.056E+07	8.252E-04	1.930E-06	2.182E+08	2.75%	74.39%
36-kr-88	7.134E+06	6.876E-05	7.680E-06	2.027E+08	2.55%	76.95%
56-ba-141	1.383E+07	6.418E-04	3.650E-06	1.868E+08	2.35%	79.30%
52-te-133	4.690E+06	9.242E-04	7.840E-06	1.360E+08	1.71%	81.01%
36-kr-87	8.855E+06	1.481E-04	4.100E-06	1.343E+08	1.69%	82.71%
35-br-84	3.831E+06	3.610E-04	9.170E-06	1.300E+08	1.64%	84.34%
52-te-131	1.624E+07	4.814E-04	2.130E-06	1.280E+08	1.61%	85.96%
54-xe-138	7.516E+06	8.252E-04	4.410E-06	1.226E+08	1.54%	87.50%
51-sb-131	8.516E+06	5.955E-04	3.180E-06	1.002E+08	1.26%	88.76%
37-rb-88	7.185E+06	6.418E-04	3.120E-06	8.294E+07	1.04%	89.81%
34-se-83	1.502E+06	4.621E-04	1.490E-05	8.281E+07	1.04%	90.85%
43-tc-102m	4.137E+06	2.567E-03	5.350E-06	8.189E+07	1.03%	91.88%
51-sb-128m	2.339E+06	1.050E-03	9.280E-06	8.031E+07	1.01%	92.89%
59-pr-145	4.535E+06	3.220E-05	4.090E-06	6.863E+07	0.86%	93.76%
56-ba-142	3.502E+06	1.155E-03	4.950E-06	6.414E+07	0.81%	94.57%
38-sr-91	3.964E+06	1.985E-05	4.180E-06	6.131E+07	0.77%	95.34%
41-nb-97m	2.475E+06	1.155E-02	3.820E-06	3.498E+07	0.44%	95.78%
58-ce-146	5.015E+06	8.311E-04	1.500E-06	2.783E+07	0.35%	96.13%
53-i-132	5.771E+05	8.371E-05	1.120E-05	2.392E+07	0.30%	96.43%
44-ru-105	1.505E+06	4.376E-05	3.880E-06	2.161E+07	0.27%	96.70%
Total:	4.266E+08			7.939E+09		

a. DCON: Decay Constant (sec^{-1})
b. ERM: Exposure Rate Multiplier ($R/hr/dis/sec/cm^2$)

Table 3-2. Upgrade DELFIC, U235 fast fission at 1 hr, 32 most important isotopes for surface exposure.

nuclide	Ci/KT	DCON[a]	ERM[b]	R/hr/KT/m^2	% of total R	Cumulative
53-i-134	2.033E+07	2.196E-04	1.254E-05	9.432E+08	11.48%	11.48%
55-cs-138	1.988E+07	3.588E-04	1.031E-05	7.586E+08	9.24%	20.72%
54-xe-134	2.033E+07	2.390E+00	9.478E-06	7.129E+08	8.68%	29.40%
57-la-142	1.890E+07	1.268E-04	9.467E-06	6.620E+08	8.06%	37.46%
52-te-133m	1.224E+07	2.085E-04	8.088E-06	3.663E+08	4.46%	41.92%
59-pr-146	1.768E+07	4.784E-04	4.556E-06	2.980E+08	3.63%	45.55%
51-sb-131	9.984E+06	5.023E-04	8.015E-06	2.961E+08	3.60%	49.15%
38-sr-92	1.234E+07	7.105E-05	6.050E-06	2.762E+08	3.36%	52.51%
42-mo-101	1.057E+07	7.913E-04	6.917E-06	2.705E+08	3.29%	55.81%
52-te-134	1.619E+07	2.764E-04	6.504E-06	2.698E+08	3.28%	59.09%
37-rb-89	7.781E+06	7.600E-04	8.757E-06	2.521E+08	3.07%	62.16%
51-sb-130	4.094E+06	2.925E-04	1.609E-05	2.438E+08	2.97%	65.13%
39-y-94	1.705E+07	6.178E-04	3.636E-06	2.294E+08	2.79%	67.92%
56-ba-141	1.409E+07	6.323E-04	4.023E-06	2.097E+08	2.55%	70.48%
43-tc-101	2.970E+07	8.136E-04	1.808E-06	1.987E+08	2.42%	72.89%
36-kr-88	6.201E+06	6.780E-05	7.879E-06	1.808E+08	2.20%	75.09%
43-tc-102m	3.902E+06	2.656E-03	1.129E-05	1.629E+08	1.98%	77.08%
43-tc-104	4.458E+06	6.313E-04	9.760E-06	1.610E+08	1.96%	79.04%
53-i-135	5.695E+06	2.931E-05	7.043E-06	1.484E+08	1.81%	80.84%
52-te-131	1.551E+07	4.621E-04	2.163E-06	1.241E+08	1.51%	82.36%
36-kr-87	8.383E+06	1.514E-04	3.344E-06	1.037E+08	1.26%	83.62%
35-br-84	3.854E+06	3.633E-04	6.970E-06	9.939E+07	1.21%	84.83%
39-y-95	5.231E+06	1.100E-03	4.963E-06	9.607E+07	1.17%	86.00%
54-xe-138	5.118E+06	8.205E-04	4.807E-06	9.102E+07	1.11%	87.11%
52-te-133	3.846E+06	9.242E-04	5.622E-06	8.000E+07	0.97%	88.08%
51-sb-128m	2.281E+06	1.111E-03	9.436E-06	7.963E+07	0.97%	89.05%
56-ba-142	4.157E+06	1.090E-03	5.162E-06	7.940E+07	0.97%	90.02%
59-pr-147	3.860E+06	8.494E-04	4.368E-06	6.238E+07	0.76%	90.78%
37-rb-88	6.170E+06	6.497E-04	2.654E-06	6.059E+07	0.74%	91.51%
38-sr-93	1.341E+06	1.556E-03	1.036E-05	5.138E+07	0.63%	92.14%
34-se-83	1.147E+06	5.180E-04	1.202E-05	5.100E+07	0.62%	92.76%
38-sr-91	4.032E+06	2.022E-05	3.323E-06	4.957E+07	0.60%	93.36%
Total:	4.185E+08			8.214E+09		

a. DCON: Decay Constant (sec^{-1})
b. ERM: Exposure Rate Multiplier ($R/hr/dis/sec/cm^2$)

Table 3-3. Original DELFIC, U238 fast fission at 1 hr, 32 most important isotopes for surface exposure.

nuclide	Ci/KT	DCON[a]	ERM[b]	R/hr/KT/m^2	% of total R	Cumulative
55-cs-138	3.387E+07	3.588E-04	9.790E-06	1.227E+09	14.78%	14.78%
53-i-134	2.325E+07	2.180E-04	1.220E-05	1.050E+09	12.64%	27.42%
52-te-133m	1.537E+07	2.310E-04	1.120E-05	6.369E+08	7.67%	35.10%
52-te-134	2.429E+07	2.751E-04	6.840E-06	6.147E+08	7.41%	42.50%
57-la-142	1.959E+07	1.375E-04	6.010E-06	4.356E+08	5.25%	47.75%
59-pr-146	1.762E+07	4.735E-04	6.530E-06	4.257E+08	5.13%	52.88%
42-mo-101	1.262E+07	7.913E-04	7.920E-06	3.698E+08	4.46%	57.34%
53-i-135	5.989E+06	2.874E-05	1.560E-05	3.457E+08	4.16%	61.50%
37-rb-89	7.338E+06	7.502E-04	1.100E-05	2.987E+08	3.60%	65.10%
57-la-143	1.264E+07	6.418E-04	5.760E-06	2.684E+08	3.23%	68.33%
43-tc-101	3.444E+07	8.252E-04	1.930E-06	2.459E+08	2.96%	71.30%
38-sr-92	9.830E+06	7.131E-05	5.880E-06	2.139E+08	2.58%	73.87%
39-y-94	1.643E+07	5.776E-04	3.480E-06	2.116E+08	2.55%	76.42%
56-ba-141	1.436E+07	6.418E-04	3.650E-06	1.939E+08	2.34%	78.76%
54-xe-138	9.543E+06	8.252E-04	6.410E-06	1.557E+08	1.88%	80.63%
52-te-133	5.150E+06	9.242E-04	7.840E-06	1.494E+08	1.80%	82.43%
36-kr-88	4.862E+06	6.876E-05	7.680E-06	1.382E+08	1.66%	84.10%
52-te-131	1.570E+07	4.814E-04	2.130E-06	1.237E+08	1.49%	85.59%
35-br-84	3.623E+06	3.610E-04	9.170E-06	1.229E+08	1.48%	87.07%
44-ru-105	8.141E+06	4.376E-05	3.880E-06	1.169E+08	1.41%	88.48%
43-tc-102m	5.750E+06	2.567E-03	5.350E-06	1.138E+08	1.37%	89.85%
51-sb-131	8.669E+06	5.955E-04	3.180E-06	1.020E+08	1.23%	91.08%
36-kr-87	6.446E+06	1.481E-04	4.100E-06	9.779E+07	1.18%	92.26%
56-ba-142	3.782E+06	1.155E-03	4.950E-06	6.927E+07	0.83%	93.09%
59-pr-145	4.418E+06	3.220E-05	4.090E-06	6.686E+07	0.81%	93.90%
37-rb-88	4.745E+06	6.418E-04	3.120E-06	5.478E+07	0.66%	94.56%
51-sb-128m	1.423E+06	1.050E-03	9.280E-06	4.886E+07	0.59%	95.14%
34-se-83	8.362E+05	4.621E-04	1.490E-05	4.610E+07	0.56%	95.70%
38-sr-91	2.894E+06	1.985E-05	4.180E-06	4.476E+07	0.54%	96.24%
41-nb-97m	2.514E+06	1.155E-02	3.820E-06	3.553E+07	0.43%	96.67%
60-nd-151	1.404E+06	8.887E-04	5.600E-06	2.909E+07	0.35%	97.02%
58-ce-146	5.089E+06	8.311E-04	1.500E-06	2.824E+07	0.34%	97.36%
	4.605E+08			8.300E+09		

a. DCON: Decay Constant (sec^{-1})
b. ERM: Exposure Rate Multiplier (R/hr/dis/sec/cm^2)

Table 3-4. Upgrade DELFIC, U238 fast fission at 1 hr, 32 most important isotopes for surface exposure.

nuclide	Ci/KT	DCON[a]	ERM[b]	R/hr/KT/m^2	% of total R	Cumulative
53-i-134	2.340E+07	2.196E-04	1.254E-05	1.086E+09	11.71%	11.71%
55-cs-138	2.661E+07	3.588E-04	1.031E-05	1.015E+09	10.95%	22.66%
54-xe-134	2.340E+07	2.390E+00	9.478E-06	8.206E+08	8.85%	31.50%
57-la-142	1.860E+07	1.268E-04	9.467E-06	6.515E+08	7.03%	38.53%
43-tc-104	1.653E+07	6.313E-04	9.760E-06	5.969E+08	6.44%	44.96%
52-te-133m	1.487E+07	2.085E-04	8.088E-06	4.450E+08	4.80%	49.76%
52-te-134	2.428E+07	2.764E-04	4.504E-06	4.046E+08	4.36%	54.13%
42-mo-101	1.188E+07	7.913E-04	6.917E-06	3.041E+08	3.28%	57.40%
51-sb-131	1.014E+07	5.023E-04	8.015E-06	3.007E+08	3.24%	60.65%
59-pr-146	1.754E+07	4.784E-04	4.556E-06	2.957E+08	3.19%	63.83%
43-tc-102m	5.423E+06	2.656E-03	1.129E-05	2.264E+08	2.44%	66.28%
43-tc-101	3.333E+07	8.136E-04	1.808E-06	2.229E+08	2.40%	68.68%
38-sr-92	9.801E+06	7.105E-05	6.050E-06	2.194E+08	2.37%	71.05%
56-ba-141	1.463E+07	6.323E-04	4.023E-06	2.178E+08	2.35%	73.39%
37-rb-89	6.511E+06	7.600E-04	8.757E-06	2.110E+08	2.27%	75.67%
39-y-94	1.523E+07	6.178E-04	3.636E-06	2.049E+08	2.21%	77.88%
53-i-135	6.082E+06	2.931E-05	7.043E-06	1.585E+08	1.71%	79.59%
51-sb-130	2.466E+06	2.925E-04	1.609E-05	1.468E+08	1.58%	81.17%
54-xe-138	7.755E+06	8.205E-04	4.807E-06	1.379E+08	1.49%	82.66%
36-kr-88	4.626E+06	6.780E-05	7.879E-06	1.349E+08	1.45%	84.11%
52-te-131	1.530E+07	4.621E-04	2.163E-06	1.224E+08	1.32%	85.43%
44-ru-105	8.068E+06	4.337E-05	3.730E-06	1.114E+08	1.20%	86.63%
52-te-133	4.625E+06	9.242E-04	5.622E-06	9.620E+07	1.04%	87.67%
35-br-84	3.646E+06	3.633E-04	6.970E-06	9.402E+07	1.01%	88.68%
39-y-95	4.884E+06	1.100E-03	4.963E-06	8.969E+07	0.97%	89.65%
56-ba-142	4.478E+06	1.090E-03	5.162E-06	8.553E+07	0.92%	90.57%
36-kr-87	6.443E+06	1.514E-04	3.344E-06	7.971E+07	0.86%	91.43%
59-pr-147	4.384E+06	8.494E-04	4.368E-06	7.085E+07	0.76%	92.20%
43-tc-102	3.371E+06	1.313E-01	4.734E-06	5.904E+07	0.64%	92.83%
51-sb-128m	1.391E+06	1.111E-03	9.436E-06	4.856E+07	0.52%	93.36%
37-rb-88	4.521E+06	6.497E-04	2.654E-06	4.440E+07	0.48%	93.83%
38-sr-93	1.141E+06	1.556E-03	1.036E-05	4.372E+07	0.47%	94.31%
	4.629E+08			9.274E+09		

a. DCON: Decay Constant (sec^{-1})
b. ERM: Exposure Rate Multiplier ($R/hr/dis/sec/cm^2$)

Table 3-5. Original DELFIC, Pu239 fast fission at 1 hr, 32 most important isotopes for surface exposure.

nuclide	Ci/KT	DCON[a]	ERM[b]	R/hr/KT/m^2	% of total R	Cumulative
55-cs-138	2.854E+07	3.588E-04	9.790E-06	1.034E+09	15.04%	15.04%
53-i-134	2.096E+07	2.180E-04	1.220E-05	9.461E+08	13.77%	28.81%
52-te-133m	1.222E+07	2.310E-04	1.120E-05	5.064E+08	7.37%	36.18%
52-te-134	1.515E+07	2.751E-04	6.840E-06	3.834E+08	5.58%	41.76%
42-mo-101	1.249E+07	7.913E-04	7.920E-06	3.660E+08	5.33%	47.09%
59-pr-146	1.326E+07	4.735E-04	6.530E-06	3.204E+08	4.66%	51.75%
57-la-142	1.431E+07	1.375E-04	6.010E-06	3.182E+08	4.63%	56.38%
53-i-135	5.259E+06	2.874E-05	1.560E-05	3.035E+08	4.42%	60.80%
43-tc-101	3.437E+07	8.252E-04	1.930E-06	2.454E+08	3.57%	64.37%
57-la-143	8.639E+06	6.418E-04	5.740E-06	1.835E+08	2.67%	67.04%
37-rb-89	4.173E+06	7.502E-04	1.100E-05	1.698E+08	2.47%	69.51%
52-te-131	1.930E+07	4.814E-04	2.130E-06	1.521E+08	2.21%	71.73%
51-sb-128m	4.245E+06	1.050E-03	9.280E-06	1.458E+08	2.12%	73.85%
39-y-94	1.129E+07	5.776E-04	3.480E-06	1.454E+08	2.12%	75.96%
56-ba-141	1.042E+07	6.418E-04	3.650E-06	1.407E+08	2.05%	78.01%
52-te-133	4.673E+06	9.242E-04	7.840E-06	1.356E+08	1.97%	79.98%
38-sr-92	6.136E+06	7.131E-05	5.880E-06	1.335E+08	1.94%	81.93%
51-sb-131	9.852E+06	5.955E-04	3.180E-06	1.159E+08	1.69%	83.61%
44-ru-105	7.762E+06	4.376E-05	3.880E-06	1.114E+08	1.62%	85.24%
43-tc-102m	5.391E+06	2.567E-03	5.350E-06	1.067E+08	1.55%	86.79%
54-xe-138	6.386E+06	8.252E-04	4.410E-06	1.042E+08	1.52%	88.31%
36-kr-88	2.888E+06	6.876E-05	7.680E-06	8.207E+07	1.19%	89.50%
35-br-84	2.149E+06	3.610E-04	9.170E-06	7.291E+07	1.06%	90.56%
36-kr-87	3.958E+06	1.481E-04	4.100E-06	6.004E+07	0.87%	91.43%
51-sb-129	2.398E+06	4.186E-05	5.400E-06	4.791E+07	0.70%	92.13%
59-pr-145	3.105E+06	3.220E-05	4.090E-06	4.699E+07	0.68%	92.82%
56-ba-142	2.423E+06	1.155E-03	4.950E-06	4.438E+07	0.65%	93.46%
34-se-83	7.659E+05	4.621E-04	1.490E-05	4.222E+07	0.61%	94.08%
37-rb-88	2.998E+06	6.418E-04	3.120E-06	3.461E+07	0.50%	94.58%
53-i-132	8.291E+05	8.371E-05	1.120E-05	3.436E+07	0.50%	95.08%
50-sn-128	3.452E+06	2.027E-04	2.390E-06	3.053E+07	0.44%	95.52%
41-nb-97m	2.126E+06	1.155E-02	3.820E-06	3.005E+07	0.44%	95.96%
	4.159E+08			6.872E+09		

a. DCON: Decay Constant (sec^{-1})
b. ERM: Exposure Rate Multiplier ($R/hr/dis/sec/cm^2$)

Table 3-6. Upgrade DELFIC, Pu239 fast fission at 1 hr, 32 most important isotopes for surface exposure.

nuclide	Ci/KT	DCON[a]	ERM[b]	R/hr/KT/m^2	% of total R	Cumulative
53-i-134	2.106E+07	2.196E-04	1.254E-05	9.771E+08	12.04%	12.04%
54-xe-134	2.106E+07	2.390E+00	9.478E-06	7.385E+08	9.10%	21.13%
55-cs-138	1.730E+07	3.588E-04	1.031E-05	6.602E+08	8.13%	29.26%
43-tc-104	1.501E+07	6.313E-04	9.760E-06	5.420E+08	6.68%	35.94%
57-la-142	1.360E+07	1.268E-04	9.467E-06	4.764E+08	5.87%	41.81%
51-sb-130	7.404E+06	2.925E-04	1.609E-05	4.408E+08	5.43%	47.24%
52-te-133m	1.188E+07	2.085E-04	8.088E-06	3.555E+08	4.38%	51.62%
51-sb-131	1.156E+07	5.023E-04	8.015E-06	3.478E+08	4.22%	55.84%
42-mo-101	1.188E+07	7.913E-04	6.917E-06	3.041E+08	3.75%	59.59%
52-te-134	1.515E+07	2.764E-04	4.504E-06	2.525E+08	3.11%	62.70%
43-tc-101	3.349E+07	8.136E-04	1.808E-06	2.240E+08	2.76%	65.45%
59-pr-146	1.320E+07	4.784E-04	4.556E-06	2.225E+08	2.74%	68.20%
43-tc-102m	5.086E+06	2.656E-03	1.129E-05	2.124E+08	2.62%	70.81%
56-ba-141	1.062E+07	6.323E-04	4.023E-06	1.581E+08	1.95%	72.76%
52-te-131	1.823E+07	4.621E-04	2.163E-06	1.459E+08	1.80%	74.56%
51-sb-128m	4.122E+06	1.111E-03	9.436E-06	1.439E+08	1.77%	76.33%
39-y-94	1.047E+07	6.178E-04	3.636E-06	1.409E+08	1.74%	78.06%
53-i-135	5.346E+06	2.931E-05	7.043E-06	1.393E+08	1.72%	79.78%
38-sr-92	6.119E+06	7.105E-05	6.050E-06	1.370E+08	1.69%	81.47%
44-ru-105	7.696E+06	4.337E-05	3.730E-06	1.062E+08	1.31%	82.77%
37-rb-89	3.035E+06	7.600E-04	8.757E-06	9.833E+07	1.21%	83.99%
45-rh-107	1.494E+07	5.324E-04	1.682E-06	9.300E+07	1.15%	85.13%
51-sb-129	3.849E+06	4.376E-05	6.458E-06	9.197E+07	1.13%	86.26%
52-te-133	3.743E+06	9.242E-04	5.622E-06	7.786E+07	0.96%	87.22%
54-xe-138	4.144E+06	8.205E-04	4.807E-06	7.370E+07	0.91%	88.13%
36-kr-88	2.406E+06	6.780E-05	7.879E-06	7.014E+07	0.86%	89.00%
39-y-95	3.575E+06	1.100E-03	4.963E-06	6.565E+07	0.81%	89.80%
35-br-84	2.161E+06	3.633E-04	6.970E-06	5.573E+07	0.69%	90.49%
43-tc-102	3.161E+06	1.313E-01	4.734E-06	5.536E+07	0.68%	91.17%
56-ba-142	2.877E+06	1.090E-03	5.162E-06	5.495E+07	0.68%	91.85%
59-pr-147	3.360E+06	8.494E-04	4.368E-06	5.430E+07	0.67%	92.52%
50-sn-128	3.417E+06	1.955E-04	3.908E-06	4.941E+07	0.61%	93.13%
	4.089E+08			8.118E+09		

a. DCON: Decay Constant (sec^{-1})
b. ERM: Exposure Rate Multiplier (R/hr/dis/sec/cm^2)

Table 3-7. Original DELFIC, U238 thermonuclear fission at 1 hr, 32 most important isotopes for surface exposure.

nuclide	Ci/KT	DCON[a]	ERM[b]	R/hr/KT/m^2	% of total R	Cumulative
55-cs-138	2.912E+07	3.588E-04	9.790E-06	1.055E+09	14.20%	14.20%
53-i-134	1.801E+07	2.180E-04	1.220E-05	8.130E+08	10.94%	25.14%
52-te-133m	1.071E+07	2.310E-04	1.120E-05	4.438E+08	5.97%	31.12%
59-pr-146	1.750E+07	4.735E-04	6.530E-06	4.228E+08	5.69%	36.81%
57-la-142	1.801E+07	1.375E-04	6.010E-06	4.005E+08	5.39%	42.20%
52-te-134	1.549E+07	2.751E-04	6.840E-06	3.920E+08	5.28%	47.48%
42-mo-101	1.023E+07	7.913E-04	7.920E-06	2.998E+08	4.04%	51.51%
53-i-135	4.995E+06	2.874E-05	1.560E-05	2.883E+08	3.88%	55.39%
51-sb-128m	8.256E+06	1.050E-03	9.280E-06	2.835E+08	3.82%	59.21%
37-rb-89	6.650E+06	7.502E-04	1.100E-05	2.707E+08	3.64%	62.85%
57-la-143	1.189E+07	6.418E-04	5.740E-06	2.525E+08	3.40%	66.25%
43-tc-101	2.789E+07	8.252E-04	1.930E-06	1.992E+08	2.68%	68.93%
39-y-96	1.519E+07	5.776E-04	3.480E-06	1.956E+08	2.63%	71.57%
38-sr-92	8.856E+06	7.131E-05	5.880E-06	1.927E+08	2.59%	74.16%
56-ba-141	1.293E+07	6.418E-04	3.650E-06	1.746E+08	2.35%	76.51%
36-kr-88	4.893E+06	6.876E-05	7.680E-06	1.390E+08	1.87%	78.38%
52-te-131	1.700E+07	4.814E-04	2.130E-06	1.340E+08	1.80%	80.19%
54-xe-138	8.134E+06	8.252E-04	4.610E-06	1.327E+08	1.79%	81.97%
52-te-133	4.066E+06	9.242E-04	7.840E-06	1.179E+08	1.59%	83.56%
35-br-84	3.298E+06	3.610E-04	9.170E-06	1.119E+08	1.51%	85.07%
51-sb-131	8.776E+06	5.955E-04	3.180E-06	1.033E+08	1.39%	86.46%
36-kr-87	6.674E+06	1.481E-04	4.100E-06	1.012E+08	1.36%	87.82%
43-tc-102m	4.461E+06	2.567E-03	5.350E-06	8.831E+07	1.19%	89.01%
44-ru-105	5.836E+06	4.376E-05	3.880E-06	8.378E+07	1.13%	90.14%
56-ba-142	3.490E+06	1.155E-03	4.950E-06	6.392E+07	0.86%	91.00%
50-sn-128	7.067E+06	2.027E-04	2.390E-06	6.249E+07	0.84%	91.84%
59-pr-145	4.105E+06	3.220E-05	4.090E-06	6.212E+07	0.84%	92.67%
34-se-83	1.033E+06	4.621E-04	1.490E-05	5.695E+07	0.77%	93.44%
37-rb-88	4.809E+06	6.418E-04	3.120E-06	5.552E+07	0.75%	94.19%
38-sr-91	2.655E+06	1.985E-05	4.180E-06	4.106E+07	0.55%	94.74%
51-sb-129	2.011E+06	4.186E-05	5.400E-06	4.018E+07	0.54%	95.28%
60-nd-151	1.577E+06	8.887E-04	5.600E-06	3.268E+07	0.44%	95.72%
Total:	4.391E+08			7.429E+09		

a. DCON: Decay Constant (sec^{-1})
b. ERM: Exposure Rate Multiplier ($R/hr/dis/sec/cm^2$)

Table 3-8. Upgrade DELFIC, U238 thermonuclear fission at 1 hr, 32 most important isotopes for surface exposure.

nuclide	Ci/KT	DCON[a]	ERM[b]	R/hr/KT/m^2	% of total R	Cumulative
55-cs-138	2.243E+07	3.588E-04	1.031E-05	8.559E+08	10.13%	10.13%
53-i-134	1.811E+07	2.196E-04	1.254E-05	8.402E+08	9.95%	20.08%
54-xe-134	1.811E+07	2.390E+00	9.478E-06	6.351E+08	7.52%	27.60%
57-la-142	1.709E+07	1.268E-04	9.467E-06	5.986E+08	7.09%	34.69%
43-tc-104	1.168E+07	6.313E-04	9.760E-06	4.218E+08	4.99%	39.66%
51-sb-130	5.322E+06	2.925E-04	1.609E-05	3.169E+08	3.75%	43.43%
52-te-133m	1.042E+07	2.085E-04	8.088E-06	3.118E+08	3.69%	47.12%
51-sb-131	1.029E+07	5.023E-04	8.015E-06	3.051E+08	3.61%	50.74%
59-pr-146	1.742E+07	4.784E-04	4.556E-06	2.936E+08	3.48%	54.21%
51-sb-128m	8.067E+06	1.111E-03	9.436E-06	2.816E+08	3.33%	57.55%
52-te-134	1.549E+07	2.764E-04	4.504E-06	2.581E+08	3.06%	60.60%
42-mo-101	9.602E+06	7.913E-04	6.917E-06	2.458E+08	2.91%	63.51%
38-sr-92	8.830E+06	7.105E-05	6.050E-06	1.977E+08	2.34%	65.85%
56-ba-141	1.317E+07	6.323E-04	4.023E-06	1.960E+08	2.32%	68.18%
39-y-94	1.409E+07	6.178E-04	3.636E-06	1.896E+08	2.24%	70.42%
43-tc-101	2.693E+07	8.136E-04	1.808E-06	1.801E+08	2.13%	72.55%
43-tc-102m	4.208E+06	2.656E-03	1.129E-05	1.757E+08	2.08%	74.63%
37-rb-89	5.394E+06	7.600E-04	8.737E-06	1.748E+08	2.07%	76.70%
53-i-135	5.075E+06	2.931E-05	7.043E-06	1.322E+08	1.57%	78.27%
36-kr-88	4.432E+06	6.780E-05	7.879E-06	1.292E+08	1.53%	79.80%
52-te-131	1.613E+07	4.621E-04	2.163E-06	1.291E+08	1.53%	81.33%
54-xe-138	6.496E+06	8.205E-04	4.807E-06	1.155E+08	1.37%	82.69%
50-sn-128	6.994E+06	1.955E-04	3.908E-06	1.011E+08	1.20%	83.89%
51-sb-129	3.932E+06	4.376E-05	6.458E-06	9.395E+07	1.11%	85.00%
35-br-84	3.317E+06	3.633E-04	6.970E-06	8.554E+07	1.01%	86.02%
36-kr-87	6.454E+06	1.514E-04	3.344E-06	7.985E+07	0.95%	86.96%
44-ru-105	5.783E+06	4.337E-05	3.730E-06	7.982E+07	0.95%	87.91%
39-y-95	4.335E+06	1.100E-03	4.963E-06	7.961E+07	0.94%	88.85%
56-ba-142	4.132E+06	1.090E-03	5.162E-06	7.892E+07	0.93%	89.78%
59-pr-147	4.494E+06	8.496E-04	4.368E-06	7.263E+07	0.86%	90.64%
52-te-133	3.279E+06	9.242E-04	5.622E-06	6.820E+07	0.81%	91.45%
45-rh-107	1.056E+07	5.324E-04	1.682E-06	6.573E+07	0.78%	92.23%
Total:	4.326E+08			8.446E+09		

a. DCON: Decay Constant (sec^{-1})
b. ERM: Exposure Rate Multiplier (R/hr/dis/sec/cm^2)

Table 3-9. Elemental constituents used in ERM calculations.

Material-Element	Density[a]	Number Density[b]
Air-	1.01E-03[c]	
Nitrogen		3.25E-02
Oxygen		8.76E-03
Argon		1.95E-04
Ground-	1.7	
Hydrogen		5.74E-03
Oxygen		2.05E-02
Aluminum		2.87E-03
Silicon		6.82E-03

a. Density: g/cm^3
b. Number Density: Atoms/barn-cm
c. Read as $1.01*10^{-3}$

Table 3-10. Exposure rate multiplier (ERM) data base.

Grp. No.	Upper Energy (MeV)	R/Hr per Gamma per $Sec-Cm^2$	Grp. No.	Upper Energy (MeV)	R/Hr per Gamma per $Sec-Cm^2$
1	1.4E+01[a]	2.814E-05	12	1.5E+00	5.618E-06
2	1.2E+01	2.463E-05	13	1.0E+00	4.178E-06
3	1.0E+01	2.115E-05	14	7.0E-01	2.977E-06
4	8.0E+00	1.857E-05	15	4.5E-01	2.013E-06
5	7.0E+00	1.684E-05	16	3.0E-01	1.181E-06
6	6.0E+00	1.505E-05	17	1.5E-01	6.403E-07
7	5.0E+00	1.320E-05	18	1.0E-01	4.268E-07
8	4.0E+00	1.126E-05	19	7.0E-02	3.532E-07
9	3.0E+00	9.679E-06	20	4.5E-02	4.200E-07
10	2.5E+00	8.519E-06	21	3.0E-02	6.343E-07
11	2.0E+00	7.153E-06	22	2.0E-02	8.771E-07
	Lower Energy Bound:			1.0E-02	

a. Read as $1.4 * 10^1$

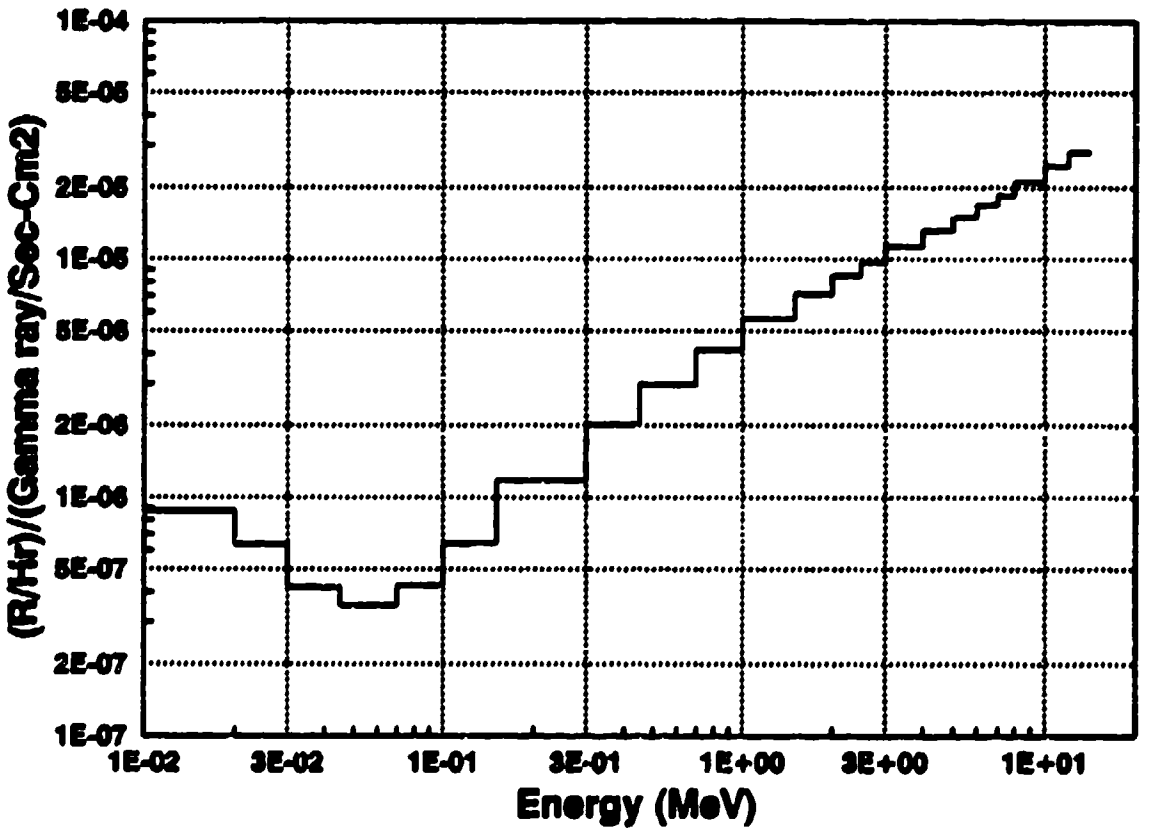

Figure 3-1. Exposure rate multiplier (ERM) data base.

SECTION 4
THE IMPACT OF DELFIC UPGRADE

Calculations have been performed with the old and upgraded DELFIC radiation physics packages to assess the aggregate effect of changes in coding and data. Tables 4-1 through 4-4 give the activity (Curies per kiloton) and exposure rate [(Roentgens per hour) per (kiloton per square meter)] calculated by DELFIC with and without upgrades for thermonuclear fission of U238 and fast fission of U235, U238 and Pu239.

4.1 ACTIVITY

It can be seen from the data in Tables 4-1 through 4-4 that the impact of the upgrade on activity inventory are small, with the changes generally resulting in small reductions in activity, particularly at late times. The amount of activity reduction caused by the upgrades is consistent with that observed for coding changes to the decay package, being of the order of a few percent. Updates in radionuclide half-lives do not appear to have had a significant net effect on activity levels. However, some effect is noticeable at early times, i.e., between one and fifteen minutes.

4.2 EXPOSURE RATE

The upgrade of Exposure Rate Multipliers (ERM), replacing the values for the 181 radionuclides in DELFIC which had ERM's and including ERM's for an additional 393 radionuclides, affects the net exposure rate as a function of time similarly for all nuclides and fission types included in Tables 4-1 through 4-4. The increase due to the upgrade in exposure rates at one minute is most dramatic, on the order of a factor of four or more. Of course fallout at one minute is not particularly important, however the change in surface exposure rate must be mirrored in that due to exposure to the rising cloud and its stem. Such early time exposure rates are potentially important to aircraft attempting to penetrate an array of clouds in the first few minutes after detonation.

Eventually, DELFIC must be reconciled at early times with such initial radiation codes as the Air Transport of Radiation (ATR) code, which calculates exposure rates from the rising cloud out to 60 seconds. ATR uses the aggregate gamma ray emission rate per fission as its source. Using this source in place of that calculated using the DELFIC inventory yields a surface exposure rate which is approximately 50% greater than that calculated by the upgraded DELFIC. Therefore, it must be assumed that the success of DELFIC-ATR reconciliation will depend not only on the upgrade of exposure rates associated with the current DELFIC inventory but also on the addition of more short-lived nuclides to that inventory. Additional fission products for which decay rates and gamma emission data are available are given in Appendix B.

At one hour, a time generally used as a standard for fallout assessment, the exposure rates of the upgraded DELFIC are generally between ten and twenty percent greater than the old values. At one day the upgraded values have dipped below the old values by approximately twenty percent. However, by one week the upgraded values have risen to within a few percent of the old values.

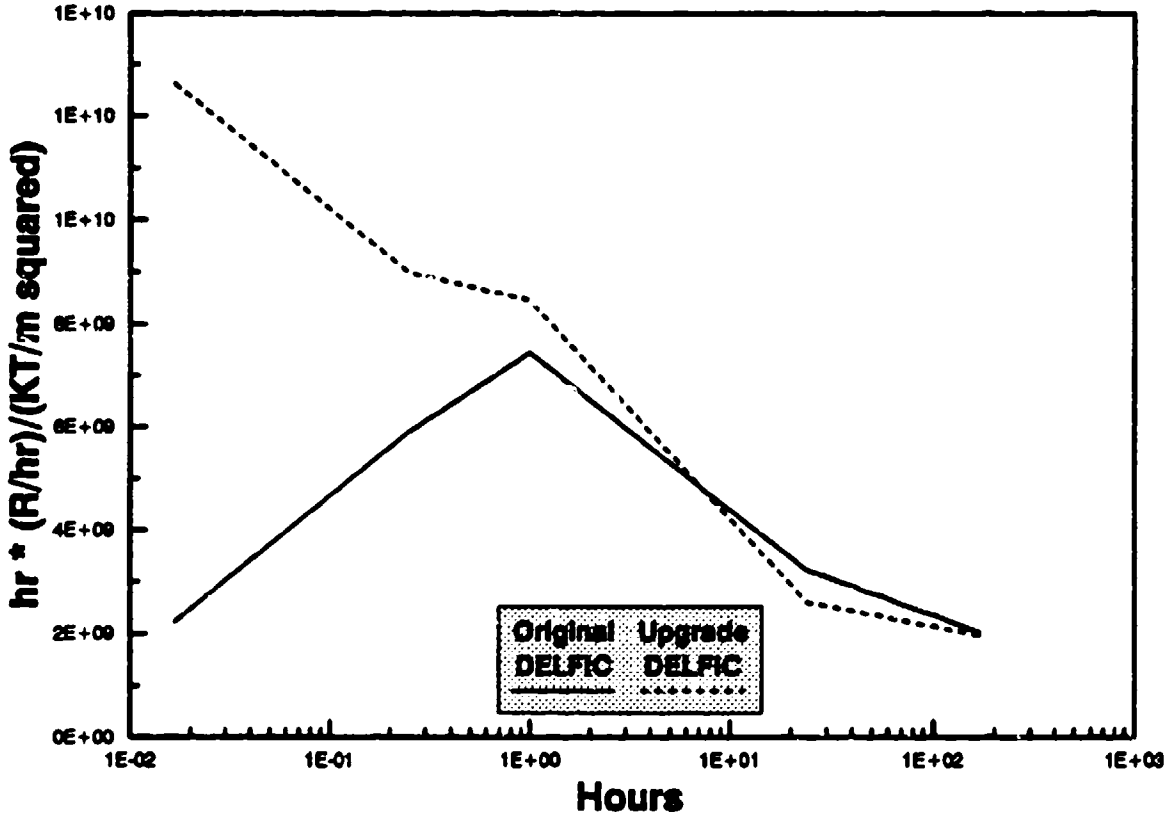

Figure 4-1. DELFIC original and updated exposure rates for U238 thermonuclear fission.

Figure 4-1 illustrates the progression of exposure rate values for U238 thermonuclear fission from one minute to one week. Exposure rate values in the figure are multiplied by time to reduce the number of decades which must be portrayed. Also, in a semi-log plot of the product of time and exposure rate versus time, the area under the curve is proportional to the time-integral exposure for any given time segment.

Figure 4-1 shows the stark contrast between early time dose accumulation as portrayed using the old and upgraded versions of DELFIC. It also illustrates the decrease in dose accumulation of the upgrade relative to the old DELFIC in the vicinity of one day.

Table 4-1. Fallout activity and exposure rates, U238 thermonuclear fission.

	Time	Curies/KT		
	(hrs)	Old	Upgrade	Diff.[a]
min	1.667E-02	3.278E+10	3.365E+10	2.65%
qtr hr	2.500E-01	2.117E+09	1.978E+09	-6.57%
hr	1.000E+00	4.391E+08	4.326E+08	-1.48%
day	2.400E+01	1.332E+07	1.298E+07	-2.55%
week	1.680E+02	1.344E+06	1.307E+06	-2.75%
	Time	(R/hr)/(KT/m^2)		
	(hrs)	Old	Upgrade	Diff.[a]
min	1.667E-02	1.336E+11	7.573E+11	466.84%
qtr hr	2.500E-01	2.365E+10	3.591E+10	51.84%
hr	1.000E+00	7.430E+09	8.447E+09	13.70%
day	2.400E+01	1.345E+08	1.086E+08	-19.31%
week	1.680E+02	1.214E+07	1.174E+07	-3.29%

a. Difference = (Upgrade-Old)/Old*100%

Table 4-2. Fallout activity and exposure rates, U235 fast fission.

	Time	Curies/KT		
	(hrs)	Old	Upgrade	Diff.[a]
min	1.667E-02	2.800E+10	2.764E+10	-1.29%
qtr hr	2.500E-01	1.870E+09	1.690E+09	-9.63%
hr	1.000E+00	4.266E+08	4.185E+08	-1.90%
day	2.400E+01	1.336E+07	1.307E+07	-2.17%
week	1.680E+02	1.327E+06	1.290E+06	-2.79%
	Time	(R/hr)/(KT/m^2)		
	(hrs)	Old	Upgrade	Diff.[a]
min	1.667E-02	1.436E+11	6.602E+11	359.75%
qtr hr	2.500E-01	2.331E+10	3.159E+10	35.53%
hr	1.000E+00	7.940E+09	8.214E+09	3.45%
day	2.400E+01	1.483E+08	1.178E+08	-20.53%
week	1.680E+02	1.328E+07	1.271E+07	-4.26%

a. Difference = (Upgrade-Old)/Old*100%

Table 4-3. Fallout activity and exposure rates, U238 fast fission.

	Time	Curies/KT		
	(hrs)	Old	Upgrade	Diff.[a]
min	1.667E-02	3.549E+10	3.658E+10	3.07%
qtr hr	2.500E-01	2.070E+09	1.910E+09	-7.73%
hr	1.000E+00	4.605E+08	4.629E+08	0.52%
day	2.400E+01	1.387E+07	1.376E+07	-0.79%
week	1.680E+02	1.389E+06	1.379E+06	-0.72%
	Time	(R/hr)/(KT/m^2)		
	(hrs)	Old	Upgrade	Diff.[a]
min	1.667E-02	1.440E+11	8.461E+11	487.57%
qtr hr	2.500E-01	2.354E+10	3.604E+10	53.11%
hr	1.000E+00	8.299E+09	9.276E+09	11.77%
day	2.400E+01	1.460E+08	1.175E+08	-19.51%
week	1.680E+02	1.294E+07	1.252E+07	-3.23%

a. Difference = (Upgrade-Old)/Old*100%

Table 4-4. Fallout activity and exposure rates, Pu239 fast fission.

	Time	Curies/KT		
	(hrs)	Old	Upgrade	Diff.[a]
min	1.667E-02	2.747E+10	2.764E+10	0.62%
qtr hr	2.500E-01	1.830E+09	1.650E+09	-9.84%
hr	1.000E+00	4.159E+08	4.089E+08	-1.68%
day	2.400E+01	1.307E+07	1.267E+07	-3.06%
week	1.680E+02	1.336E+06	1.291E+06	-3.37%
	Time	(R/hr)/(KT/m^2)		
	(hrs)	Old	Upgrade	Diff.[a]
min	1.667E-02	1.017E+11	6.033E+11	493.22%
qtr hr	2.500E-01	1.949E+10	2.933E+10	50.45%
hr	1.000E+00	6.871E+09	8.118E+09	18.15%
day	2.400E+01	1.339E+08	1.099E+08	-17.96%
week	1.680E+02	1.293E+07	1.248E+07	-3.46%

a. Difference = (Upgrade-Old)/Old*100%

SECTION 5
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APPENDIX A
DECAY CONSTANTS AND ERM'S

This appendix contains a listing of all the decay constants and exposure rate multipliers (ERM's) in the original DELFIC and in the upgraded version of the code.

Table A-1. DELFIC original and upgrade decay constants and exposure rate multipliers, 72 ≤ Mass No. ≤ 77.

At. Wt.	Nuclide	Decay Constant (sec^{-1}) Original	Upgrade	ERM ($R/hr/KT/m^2$) Original	Upgrade
72	27-co-72	6.93E+01	5.61026E+00		1.30617E-05
72	28-ni-72	1.98E-01	1.80950E-01		4.16928E-06
72	29-cu-72	6.93E-02	1.06817E-01		1.07628E-05
72	30-zn-72	4.14E-06	4.14066E-06	8.40E-07	8.70428E-07
72	31-ga-72	1.37E-05	1.36554E-05	1.17E-05	1.17032E-05
72	32-ge-72	0.00E+00	0.00000E+00		0.00000E+00
73	27-co-73	6.93E+01	5.37407E+00		1.06583E-05
73	28-ni-73	3.47E-01	1.41288E+00		6.20690E-06
73	29-cu-73	9.90E-02	1.35550E-01		3.39603E-06
73	30-zn-73	5.78E-03	2.94956E-02		5.37095E-06
73	31-ga-73	4.01E-05	3.96175E-05	1.89E-06	1.76594E-06
73.1	32-ge-73m	1.31E+00	1.38907E+00	7.79E-08	8.02508E-08
73	32-ge-73	0.00E+00	0.00000E+00		0.00000E+00
74	27-co-74	6.93E+01	7.53724E+00		1.77638E-05
74	28-ni-74	4.62E-01	7.70035E-01		5.20376E-06
74	29-cu-74	1.73E-01	1.06937E+00		1.13898E-05
74	30-zn-74	2.57E-03	7.22028E-03	3.65E-06	4.38871E-06
74	31-ga-74	1.48E-03	1.42272E-03	1.80E-05	1.27482E-05
74	32-ge-74	0.00E+00	0.00000E+00		0.00000E+00
75	27-co-75	6.93E+01	8.48852E+00		1.28527E-05
75	28-ni-75	6.93E+01	2.99830E+00		8.24451E-06
75	29-cu-75	2.77E-01	7.47441E-01		4.40961E-06
75	30-zn-75	7.30E-02	6.79556E-02		8.39080E-06
75	31-ga-75	5.78E-03	5.50117E-03		1.75549E-06
75.1	32-ge-75m	1.41E-02	1.45314E-02	3.03E-07	2.99896E-07
75	32-ge-75	1.41E-04	1.39556E-04	1.99E-07	1.83908E-07
75	33-as-75	0.00E+00	0.00000E+00		0.00000E+00
76	28-ni-76	6.93E+01	2.27590E+00		6.29049E-06
76	29-cu-76	3.47E-01	2.66339E+00		1.22257E-05
76	30-zn-76	8.66E-02	1.23776E-01		3.64681E-06
76	31-ga-76	2.31E-02	2.12622E-02		1.12853E-05
76	32-ge-76	0.00E+00	0.00000E+00		0.00000E+00
76	33-as-76	7.27E-06	7.31538E-06	2.10E-06	2.06897E-06
76	34-se-76	0.00E+00	0.00000E+00		0.00000E+00
77	28-ni-77	6.93E+01	6.70939E+00		1.08673E-05
77	29-cu-77	4.62E-01	2.27098E+00		5.71578E-06
77	30-zn-77	1.98E-01	3.33244E-01		8.07732E-06
77	31-ga-77	4.62E-02	5.25112E-02		3.52142E-06
77.1	32-ge-77m	1.28E-02	1.31030E-02	4.04E-07	3.43783E-07
77	32-ge-77	1.70E-05	1.70390E-05	5.74E-06	5.06792E-06
77	33-as-77	4.98E-06	4.95856E-06	5.53E-08	3.92894E-08
77	34-se-77	0.00E+00	0.00000E+00		0.00000E+00

Table A-2. DELFIC original and upgrade decay constants and exposure rate multipliers, 78 ≤ Mass No. ≤ 82.

At. Wt.	Nuclide	Decay Constant (sec^{-1}) Original	Upgrade	ERM ($R/hr/KT/m^2$) Original	Upgrade
78	28-ni-78	6.93E+01	5.25948E+00		7.30408E-06
78	29-cu-78	6.93E+01	5.88061E+00		1.35841E-05
78	30-zn-78	2.77E-01	4.71529E-01		7.16823E-06
78	31-ga-78	8.66E-02	1.36178E-01		1.09718E-05
78	32-ge-78	9.17E-05	1.31278E-04	2.43E-06	1.46290E-06
78.1	33-as-78m	1.93E-03	1.92541E-03	2.71E-06	0.00000E+00
78	33-as-78	1.27E-04	1.27370E-04	4.28E-06	6.21735E-06
78	34-se-78	0.00E+00	0.00000E+00		0.00000E+00
79	29-cu-79	6.93E+01	5.13214E+00		7.06374E-06
79	30-zn-79	4.62E-01	6.93147E-01		1.08673E-05
79	31-ga-79	1.54E-01	2.31049E-01		8.45350E-06
79	32-ge-79	2.77E-02	3.62904E-02		1.82863E-06
79	33-as-79	1.28E-03	1.28218E-03		1.44201E-07
79.1	34-se-79m	2.97E-03	2.95459E-03	1.04E-07	3.13480E-07
79	34-se-79	3.66E-13	6.65604E-13		0.00000E+00
79	35-br-79	0.00E+00	0.00000E+00		0.00000E+00
80	29-cu-80	6.93E+01	7.71218E+00		1.45246E-05
80	30-zn-80	4.62E-01	1.28361E+00		5.21421E-06
80	31-ga-80	2.31E-01	4.17559E-01		1.48380E-05
80	32-ge-80	2.77E-02	2.34965E-02		2.82132E-06
80	33-as-80	1.93E-02	4.56018E-02		3.65726E-06
80	34-se-80	0.00E+00	0.00000E+00		0.00000E+00
81	29-cu-81	6.93E+01	9.34047E+00		1.14943E-05
81	30-zn-81	6.93E+01	5.64682E+00		9.46708E-06
81	31-ga-81	3.47E-01	5.63534E-01		9.25810E-06
81	32-ge-81	9.90E-02	9.12036E-02		3.62591E-06
81	33-as-81	2.10E-02	2.08152E-02		1.10763E-06
81.1	34-se-81m	2.03E-04	2.01790E-04	1.15E-07	3.19749E-07
81	34-se-81	6.42E-04	6.26149E-04		3.08255E-08
81	35-br-81	0.00E+00	0.00000E+00		0.00000E+00
82	30-zn-82	6.93E+01	5.46819E+00		8.27586E-06
82	31-ga-82	4.62E-01	1.15525E+00		1.36886E-05
82	32-ge-82	1.39E-01	1.50684E-01		3.60502E-06
82	33-as-82	3.85E-02	3.62904E-02		4.16928E-06
82	34-se-82	0.00E+00	0.00000E+00		0.00000E+00
82	35-br-82	5.36E-06	5.45442E-06	1.43E-05	1.28527E-05
82	36-kr-82	0.00E+00	0.00000E+00		0.00000E+00

Table A-3. DELFIC original and upgrade decay constants and exposure rate multipliers, 83 ≤ Mass No. ≤ 87.

At. Wt.	Nuclide	Decay Constant (sec^{-1}) Original	Upgrade	ERM ($R/hr/KT/m^2$) Original	Upgrade
83	30-zn-83	6.93E+01	8.28737E+00		1.35841E-05
83	31-ga-83	6.93E+01	2.23596E+00		1.30617E-05
83	32-ge-83	3.47E-01	3.64814E-01		9.31034E-06
83	33-as-83	9.90E-02	5.17274E-02		1.21212E-05
83.1	34-se-83m	1.00E-02	9.88798E-03	6.66E-07	4.29467E-06
83	34-se-83	4.62E-04	5.18047E-04	1.49E-05	1.20167E-05
83	35-br-83	8.02E-05	8.02254E-05	2.77E-07	3.56322E-08
83.1	36-kr-83m	1.01E-04	1.05214E-04	2.32E-07	1.14943E-07
83	36-kr-83	0.00E+00	0.00000E+00		0.00000E+00
84	31-ga-84	6.93E+01	7.04575E+00		1.51515E-05
84	32-ge-84	4.62E-01	5.77623E-01		1.03344E-05
84	33-as-84	1.73E-01	1.26027E-01		6.52038E-06
84	34-se-84	3.85E-03	3.61014E-03		2.25705E-06
84	35-br-84	3.61E-04	3.63285E-04	9.17E-06	6.96970E-06
84	36-kr-84	0.00E+00	0.00000E+00		0.00000E+00
85	31-ga-85	6.93E+01	7.97005E+00		1.46290E-05
85	32-ge-85	6.93E-01	2.77303E+00		1.18077E-05
85	33-as-85	1.61E+00	3.41789E-01		1.00313E-05
85	34-se-85	1.73E-02	2.18658E-02		8.51620E-06
85	35-br-85	3.85E-03	4.02524E-03		3.13480E-07
85.1	36-kr-85m	4.38E-05	4.29779E-05	9.09E-07	8.69383E-07
85	36-kr-85	2.07E-09	2.04897E-09	2.77E-08	1.15987E-08
85	37-rb-85	0.00E+00	0.00000E+00		0.00000E+00
86	32-ge-86	6.93E+01	2.80899E+00		1.05538E-05
86	33-as-86	3.47E-01	7.70164E-01		1.27482E-05
86	34-se-86	4.33E-02	4.53037E-02		8.76698E-06
86	35-br-86	1.16E-02	1.25798E-02		1.24347E-05
86	36-kr-86	0.00E+00	0.00000E+00		0.00000E+00
86.1	37-rb-86m	1.11E-02	1.13593E-02	2.99E-06	4.17973E-07
86	37-rb-86	4.31E-07	4.30601E-07	4.75E-07	2.83177E-06
86	38-sr-86	0.00E+00	0.00000E+00		0.00000E+00
87	32-ge-87	6.93E+01	5.17544E+00		1.29572E-05
87	33-as-87	4.62E-01	2.31049E+00		1.13898E-05
87	34-se-87	4.33E-02	1.23776E-01		1.05538E-05
87	35-br-87	1.27E-02	1.24465E-02		1.20167E-05
87	36-kr-87	1.48E-04	1.51388E-04	4.10E-06	3.34378E-06
87	37-rb-87	1.00E-15	4.57604E-19		0.00000E+00
87	38-sr-87	0.00E+00	0.00000E+00		0.00000E+00

Table A-4. DELFIC original and upgrade decay constants and exposure rate multipliers, 88 ≤ Mass No. ≤ 92.

At. Wt.	Nuclide	Decay Constant (sec^{-1}) Original	Upgrade	ERM ($R/hr/KT/m^2$) Original	Upgrade
88	32-ge-88	6.93E+01	5.37323E+00		1.15987E-05
88	33-as-88	6.93E+01	5.14090E+00		1.44201E-05
88	34-se-88	2.77E-01	4.62098E-01		8.77743E-06
88	35-br-88	4.25E-02	4.20089E-02		1.18077E-05
88	36-kr-88	6.88E-05	6.77961E-05	7.68E-06	7.87879E-06
88	37-rb-88	6.42E-04	6.49744E-04	3.12E-06	2.65413E-06
88	38-sr-88	0.00E+00	0.00000E+00		0.00000E+00
89	33-as-89	6.93E+01	5.71668E+00		1.13898E-05
89	34-se-89	3.47E-01	1.69060E+00		7.25183E-06
89	35-br-89	1.58E-01	1.58615E-01		1.21212E-05
89	36-kr-89	3.61E-03	3.64431E-03	1.69E-05	7.63845E-06
89	37-rb-89	7.50E-04	7.60030E-04	1.10E-05	8.75653E-06
89	38-sr-89	1.59E-07	1.58705E-07		0.00000E+00
89.1	39-y-89m	4.33E-02	4.31598E-02		4.43051E-06
89	39-y-89	0.00E+00	0.00000E+00		0.00000E+00
90	33-as-90	6.93E+01	7.60730E+00		1.44201E-05
90	34-se-90	6.93E+01	1.62250E+00		1.08673E-05
90	35-br-90	4.33E-01	3.61014E-01		1.23302E-05
90	36-kr-90	2.10E-02	2.14464E-02	8.99E-06	5.56949E-06
90	37-rb-90	4.28E-03	4.53037E-03		7.71160E-06
90	38-sr-90	7.84E-10	7.80284E-10		0.00000E+00
90	39-y-90	2.99E-06	3.00376E-06		9.86416E-11
90	40-zr-90	0.00E+00	0.00000E+00		0.00000E+00
91	34-se-91	6.93E+01	2.56721E+00		1.12853E-05
91	35-br-91	3.47E-01	1.15525E+00		8.08777E-06
91	36-kr-91	6.93E-02	8.08807E-02		7.27273E-06
91	37-rb-91	9.63E-03	1.18690E-02		8.48485E-06
91	38-sr-91	1.98E-05	2.02249E-05	4.18E-06	3.32288E-06
91.1	39-y-91m	2.31E-04	2.32397E-04	2.82E-06	2.75862E-06
91	39-y-91	1.38E-07	1.37114E-07	1.73E-08	1.61964E-08
91	40-zr-91	0.00E+00	0.00000E+00		0.00000E+00
92	34-se-92	6.93E+01	4.12122E+00		8.73563E-06
92	35-br-92	4.62E-01	1.89903E+00		1.10763E-05
92	36-kr-92	2.31E-01	3.74674E-01		6.63532E-06
92	37-rb-92	1.31E-01	1.54033E-01		1.75549E-06
92	38-sr-92	7.13E-05	7.10483E-05	5.88E-06	6.05016E-06
92	39-y-92	5.35E-05	5.43901E-05	1.22E-06	1.21212E-06
92	40-zr-92	0.00E+00	0.00000E+00		0.00000E+00

Table A-5. DELFIC original and upgrade decay constants and exposure rate multipliers, 93 ≤ Mass No. ≤ 97.

At. Wt.	Nuclide	Decay Constant (sec^{-1}) Original	Upgrade	ERM ($R/hr/KT/m^2$) Original	Upgrade
93	34-se-93	6.93E+01	7.16305E+00		1.46290E-05
93	35-br-93	6.93E+01	3.93208E+00		1.32706E-05
93	36-kr-93	3.47E-01	5.37323E-01		9.19540E-06
93	37-rb-93	1.24E-01	1.21605E-01		5.16196E-06
93	38-sr-93	1.44E-03	1.55631E-03	1.14E-06	1.03553E-05
93	39-y-93	1.93E-05	1.90635E-05	4.88E-07	4.04389E-07
93	40-zr-93	2.31E-14	1.43562E-14		0.00000E+00
93.1	41-nb-93m	5.94E-09	1.36175E-09	1.66E-07	1.06583E-07
93	41-nb-93	0.00E+00	0.00000E+00		0.00000E+00
94	35-br-94	6.93E+01	5.25584E+00		1.57785E-05
94	36-kr-94	4.95E-01	3.30070E+00		6.19645E-06
94	37-rb-94	2.31E-01	2.56531E-01		1.66144E-05
94	38-sr-94	8.89E-03	9.21738E-03		6.43678E-06
94	39-y-94	5.78E-04	6.17778E-04	3.48E-06	3.63636E-06
94	40-zr-94	0.00E+00	0.00000E+00		0.00000E+00
95	35-br-95	6.93E+01	6.48528E+00		1.31661E-05
95	36-kr-95	6.93E+01	8.88650E-01		1.24347E-05
95	37-rb-95	3.47E-01	1.80507E+00		1.36886E-05
95	38-sr-95	1.73E-02	2.76154E-02		8.03553E-06
95	39-y-95	1.16E-03	1.10023E-03		4.96343E-06
95	40-zr-95	1.23E-07	1.25313E-07	3.78E-06	3.59457E-06
95.1	41-nb-95m	2.14E-06	2.22231E-06	1.33E-06	7.15778E-07
95	41-nb-95	2.29E-07	2.29412E-07	3.91E-06	3.76176E-06
95	42-mo-95	0.00E+00	0.00000E+00		0.00000E+00
96	35-br-96	6.93E+01	7.80439E+00		1.58830E-05
96	36-kr-96	6.93E+01	2.36488E+00		6.33229E-06
96	37-rb-96	6.93E-01	3.48315E+00		1.87043E-05
96	38-sr-96	2.77E-01	6.53912E-01		6.10240E-06
96.1	39-y-96m	5.02E-03	7.22028E-02		1.77638E-05
96	40-zr-96	0.00E+00	0.00000E+00		0.00000E+00
96	41-nb-96	8.37E-06	8.24586E-06	1.15E-05	1.19122E-05
96	42-mo-96	0.00E+00	0.00000E+00		0.00000E+00
97	36-kr-97	6.93E+01	6.93147E+00		1.06583E-05
97	37-rb-97	6.93E+01	4.03462E+00		1.84953E-05
97	38-sr-97	4.62E-01	1.65035E+00		9.62382E-06
97.1	39-y-97m	1.39E-01	5.63534E-01		1.56740E-05
97	40-zr-97	1.13E-05	1.13930E-05	2.38E-07	9.08046E-07
97.1	41-nb-97m	1.16E-02	1.15525E-02	3.82E-06	3.59457E-06
97	41-nb-97	1.58E-04	1.60228E-04	3.50E-06	3.43783E-06
97	42-mo-97	0.00E+00	0.00000E+00		0.00000E+00

Table A-6. DELFIC original and upgrade decay constants and exposure rate multipliers, 98 ≤ Mass No. ≤ 102.

At. Wt.	Nuclide	Decay Constant (sec^{-1}) Original	Upgrade	ERM (R/hr / KT/m^2) Original	Upgrade
98	36-kr-98	6.93E+01	4.32595E+00		7.28318E-06
98	37-rb-98	6.93E+01	6.08024E+00		1.04075E-05
98	38-sr-98	6.93E-01	1.06638E+00		5.54859E-06
98.1	39-y-98m	2.77E-01	3.46574E-01		1.38976E-05
98	40-zr-98	1.16E-02	2.25781E-02		8.39080E-07
98.1	41-nb-98m	2.27E-04	2.25194E-04		1.26437E-05
98	41-nb-98	5.78E-03	2.42359E-01		5.05747E-06
98	42-mo-98	0.00E+00	0.00000E+00		0.00000E+00
99	37-rb-99	6.93E+01	1.17483E+01		9.57158E-06
99	38-sr-99	6.93E-01	2.55774E+00		1.07628E-05
99	39-y-99	4.62E-01	4.71529E-01		6.16510E-06
99	40-zr-99	4.33E-01	3.30070E-01		5.65308E-06
99.1	41-nb-99m	5.02E-03	4.44325E-03		7.10554E-06
99	42-mo-99	2.90E-06	2.91994E-06	6.58E-07	1.42111E-06
99.1	43-tc-99m	3.21E-05	3.20368E-05	7.45E-07	7.12644E-07
99	43-tc-99	1.05E-13	1.04050E-13		8.00418E-12
99	44-ru-99	0.00E+00	0.00000E+00		0.00000E+00
100	38-sr-100	6.93E+01	3.43142E+00		5.83072E-06
100	39-y-100	4.62E-01	9.43057E-01		9.77011E-06
100	40-zr-100	1.98E-01	9.76264E-02		3.49007E-06
100	41-nb-100	3.85E-03	4.62098E-01		3.35423E-06
100	42-mo-100	0.00E+00	0.00000E+00		0.00000E+00
100	43-tc-100	4.33E-02	4.38701E-02	6.07E-06	4.17973E-07
100	44-ru-100	0.00E+00	0.00000E+00		0.00000E+00
101	38-sr-101	6.93E+01	3.57016E+00		9.77011E-06
101	39-y-101	6.93E-01	1.38629E+00		5.80982E-06
101	40-zr-101	2.77E-01	3.46574E-01		4.48276E-06
101	41-nb-101	1.16E-02	9.76264E-02		3.31243E-06
101	42-mo-101	7.91E-04	7.91264E-04	7.92E-06	6.91745E-06
101	43-tc-101	8.25E-04	8.13553E-04	1.93E-06	1.80773E-06
101	44-ru-101	0.00E+00	0.00000E+00		0.00000E+00
102	38-sr-102	6.93E+01	2.41422E+00		6.43678E-06
102	39-y-102	6.93E+01	7.70164E-01		1.33751E-05
102	40-zr-102	3.47E-01	2.39016E-01		3.45873E-06
102.1	41-nb-102m	9.90E-02	1.61197E-01		5.53814E-06
102	42-mo-102	1.00E-03	1.02234E-03		2.56008E-07
102.1	43-tc-102m	2.57E-03	2.65574E-03	5.35E-06	1.12853E-05
102	43-tc-102	1.39E-01	1.31278E-01		4.73354E-06
102	44-ru-102	0.00E+00	0.00000E+00		0.00000E+00

Table A-7. DELFIC original and upgrade decay constants and exposure rate multipliers, 103 ≤ Mass No. ≤ 106.

At. Wt.	Nuclide	Decay Constant (sec^{-1}) Original	Upgrade	ERM ($R/hr/KT/m^2$) Original	Upgrade
103	39-y-103	6.93E+01	2.66175E+00		7.37722E-06
103	40-zr-103	4.62E-01	5.33190E-01		5.80982E-06
103	41-nb-103	1.73E-01	4.62098E-01		4.23197E-06
103	42-mo-103	2.77E-02	1.02688E-02		4.29467E-06
103	43-tc-103	9.63E-03	1.27887E-02		2.86311E-06
103	44-ru-103	2.02E-07	2.04344E-07	2.61E-06	2.57053E-06
103.1	45-rh-103m	2.03E-04	2.05853E-04		3.90805E-08
103	45-rh-103	0.00E+00	0.00000E+00	1.22E-07	0.00000E+00
104	39-y-104	6.93E+01	5.40466E+00		1.29572E-05
104	40-zr-104	6.93E+01	2.69414E-01		4.03344E-06
104	41-nb-104	2.31E-01	1.44406E-01		1.26437E-05
104	42-mo-104	4.62E-03	1.15525E-02		4.49321E-06
104	43-tc-104	6.42E-04	6.31282E-04		9.75967E-06
104	44-ru-104	0.00E+00	0.00000E+00		0.00000E+00
104.1	45-rh-104m	2.63E-03	2.66186E-03	2.15E-07	5.29781E-07
104	45-rh-104	1.65E-02	1.63865E-02	3.00E-06	6.68757E-08
104	46-pd-104	0.00E+00	0.00000E+00		0.00000E+00
105	39-y-105	6.93E+01	4.71914E+00		8.67294E-06
105	40-zr-105	6.93E+01	1.40703E+00		6.82341E-06
105	41-nb-105	3.47E-01	2.34965E-01		5.75758E-06
105	42-mo-105	5.78E-03	1.94704E-02		6.36364E-06
105	43-tc-105	1.28E-03	1.52006E-03		3.78265E-06
105	44-ru-105	4.38E-05	4.33651E-05	3.88E-06	3.73041E-06
105.1	45-rh-105m	1.82E-02	1.54033E-02	4.17E-07	3.42738E-07
105	45-rh-105	5.35E-06	5.44516E-06	1.75E-07	4.16928E-07
105	46-pd-105	0.00E+00	0.00000E+00		0.00000E+00
106	39-y-106	6.93E+01	7.75090E+00		1.42111E-05
106	40-zr-106	6.93E+01	7.64144E-01		4.75444E-06
106	41-nb-106	4.62E-01	6.93147E-01		9.38349E-06
106	42-mo-106	1.73E-01	8.25175E-02		3.69906E-06
106	43-tc-106	7.70E-02	1.92541E-02		1.12853E-05
106	44-ru-106	2.20E-08	2.15897E-08		0.00000E+00
106.1	45-rh-106m	8.75E-05	8.88650E-05	8.68E-06	1.35841E-05
106	45-rh-106	2.31E-02	2.32600E-02	1.48E-06	1.04180E-06
106	46-pd-106	0.00E+00	0.00000E+00		0.00000E+00

Table A-8. DELFIC original and upgrade decay constants and exposure rate multipliers, 107 ≤ Mass No. ≤ 110.

At. Wt.	Nuclide	Decay Constant (sec^{-1}) Original	Upgrade	ERM ($R/hr/KT/m^2$) Original	Upgrade
107	40-zr-107	6.93E+01	2.85304E+00		8.31766E-06
107	41-nb-107	6.93E-01	9.04833E-01		7.18913E-06
107	42-mo-107	2.77E-01	1.98042E-01		5.87252E-06
107	43-tc-107	1.16E-02	3.26956E-02		6.78161E-06
107	44-ru-107	2.51E-03	3.08065E-03	1.22E-06	2.94671E-06
107.1	45-rh-107m	1.54E-02	1.54033E-02	1.74E-06	0.00000E+00
107	45-rh-107	5.25E-04	5.32371E-04		1.68234E-06
107	46-pd-107	3.14E-15	3.37923E-15		0.00000E+00
107	47-ag-107	0.00E+00	0.00000E+00		0.00000E+00
108	40-zr-108	6.93E+01	1.83338E+00		5.62173E-06
108	41-nb-108	6.93E+01	2.86070E+00		1.12853E-05
108	42-mo-108	3.47E-01	4.62098E-01		5.50679E-06
108	43-tc-108	1.16E-02	1.34071E-01		1.23302E-05
108	44-ru-108	2.69E-03	2.53900E-03	2.65E-07	3.28109E-07
108	45-rh-108	3.85E-02	4.12588E-02	2.36E-06	5.36050E-06
108		0.00E+00	0.00000E+00		0.00000E+00
109	40-zr-109	6.93E+01	5.33272E+00		9.93730E-06
109	41-nb-109	6.93E+01	2.19789E+00		8.65204E-06
109	42-mo-109	4.62E-01	4.92117E-01		7.59666E-06
109	43-tc-109	2.77E-01	4.95105E-01		4.76489E-06
109.1	44-ru-109m	4.33E-02	5.33190E-02		5.47544E-06
109.1	45-rh-109m	1.39E-02	1.38629E-02	6.37E-07	0.00000E+00
109	45-rh-109	2.31E-02	8.66434E-03		1.71369E-06
109.1	46-pd-109m	2.46E-03	2.46321E-03	6.91E-07	6.85475E-07
109	46-pd-109	1.38E-05	1.40541E-05	1.69E-07	3.36468E-09
109.1	47-ag-109m	1.78E-02	1.75037E-02	8.05E-08	2.08986E-07
109	47-ag-109	0.00E+00	0.00000E+00		0.00000E+00
110	41-nb-110	6.93E+01	5.34053E+00		1.31661E-05
110	42-mo-110	6.93E-01	2.50044E-01		5.26646E-06
110	43-tc-110	3.47E-01	8.35117E-01		8.19227E-06
110	44-ru-110	6.93E-02	4.62098E-02		3.06165E-06
110	45-rh-110	1.39E-01	2.19350E-01		4.55590E-06
110	46-pd-110	0.00E+00	0.00000E+00		0.00000E+00

Table A-9. DELFIC original and upgrade decay constants and exposure rate multipliers, 111 ≤ Mass No. ≤ 115.

At. Wt.	Nuclide	Decay Constant (sec^{-1}) Original	Upgrade	ERM ($R/hr/KT/m^2$) Original	Upgrade
111	41-nb-111	6.93E+01	4.03391E+00		9.58203E-06
111	42-mo-111	6.93E+01	1.48626E+00		9.37304E-06
111	43-tc-111	4.62E-01	3.49651E-01		6.13375E-06
111	44-ru-111	1.73E-01	4.33217E-01		4.24242E-06
111	45-rh-111	5.78E-02	6.30134E-02		4.37827E-06
111.1	46-pd-111m	3.50E-05	3.50074E-05	3.40E-07	1.89133E-06
111	46-pd-111	5.02E-04	4.93695E-04	8.90E-07	2.20481E-07
111.1	47-ag-111m	9.37E-03	1.06967E-02	3.77E-07	1.23302E-07
111	47-ag-111	1.06E-06	1.07685E-06	1.31E-07	1.42111E-07
111	48-cd-111	0.00E+00	0.00000E+00		0.00000E+00
112	42-mo-112	6.93E+01	7.10651E-01		5.95611E-06
112	43-tc-112	4.62E-01	1.60689E+00		1.02403E-05
112	44-ru-112	2.31E-01	1.92541E-01		3.55277E-06
112	45-rh-112	9.90E-02	4.62098E-01		4.49321E-06
112	46-pd-112	9.17E-06	9.14901E-06	1.25E-07	2.81087E-07
112	47-ag-112	6.02E-05	6.13188E-05	3.24E-06	3.17659E-06
112	48-cd-112	0.00E+00	0.00000E+00		0.00000E+00
113	42-mo-113	6.93E+01	3.03134E+00		1.05538E-05
113	43-tc-113	6.93E+01	1.06249E+00		7.17868E-06
113	44-ru-113	3.47E-01	2.31049E-01		5.82027E-06
113	45-rh-113	1.73E-01	7.70164E-01		3.68861E-06
113	46-pd-113	8.25E-03	7.45320E-03		3.01985E-06
113.1	47-ag-113m	9.63E-03	1.00895E-02		6.39498E-07
113	47-ag-113	3.63E-05	3.58549E-05		3.71996E-07
113	48-cd-113	0.00E+00	2.36183E-24		0.00000E+00
114	42-mo-114	6.93E+01	1.84030E+00		6.63532E-06
114	43-tc-114	6.93E+01	3.42701E+00		1.17032E-05
114	44-ru-114	4.62E-01	8.51898E-02		3.97074E-06
114	45-rh-114	2.31E-01	4.07734E-01		6.68757E-06
114	46-pd-114	4.81E-03	4.71529E-03		4.48276E-07
114	47-ag-114	1.39E-01	1.50684E-01		9.20585E-07
114	48-cd-114	0.00E+00	0.00000E+00		0.00000E+00
115	43-tc-115	6.93E+01	2.56300[illegible]+00		8.19227E-06
115	44-ru-115	6.93E-01	7.89060E-01		7.14734E-06
115	45-rh-115	2.77E-01	8.33570E-02		4.47231E-06
115	46-pd-115	1.54E-02	1.82407E-02		5.64263E-06
115.1	47-ag-115m	3.47E-02	3.85082E-02		4.35737E-06
115	47-ag-115	5.50E-04	5.77623E-04		2.15256E-06
115.1	48-cd-115m	1.87E-07	1.79878E-07	1.77E-07	1.56740E-07
115	48-cd-115	3.63E-06	3.60159E-06	1.04E-06	1.01567E-06
115.1	49-in-115m	4.27E-05	4.29204E-05	1.02E-06	1.03239E-06
115	49-in-115	1.00E-15	4.98072E-23		0.00000E+00
115	50-sn-115	0.00E+00	0.00000E+00		0.00000E+00

Table A-10. DELFIC original and upgrade decay constants and exposure rate multipliers, 116 ≤ Mass No. ≤ 120.

At. Wt.	Nuclide	Decay Constant (sec^{-1}) Original	Upgrade	ERM ($R/hr/KT/m^2$) Original	Upgrade
116	43-tc-116	6.93E+01	6.00179E+00		1.21212E-05
116	44-ru-116	6.93E+01	4.07638E-01		4.39916E-06
116	45-rh-116	3.47E-01	7.30251E-01		8.28631E-06
116	46-pd-116	6.93E-02	5.44927E-02		3.11390E-06
116.1	47-ag-116m	4.62E-03	6.66488E-02	6.43E-06	1.24347E-05
116	48-cd-116	0.00E+00	0.00000E+00		0.00000E+00
117	43-tc-117	6.93E+01	4.56739E+00		8.80878E-06
117	44-ru-117	6.93E+01	2.02219E+00		7.73250E-06
117	45-rh-117	4.62E-01	5.69367E-01		5.42320E-06
117	46-pd-117	1.39E-01	1.38629E-01		4.58725E-06
117	47-ag-117	1.05E-02	9.52125E-03		5.39185E-06
117.1	48-cd-117m	6.42E-05	5.73038E-05	7.08E-06	8.81923E-06
117	48-cd-117	2.31E-04	7.73257E-05		4.97388E-06
117.1	49-in-117m	9.63E-05	9.91627E-05	5.25E-07	5.82027E-07
117	49-in-117	2.57E-04	2.63755E-04	3.85E-06	3.62591E-06
117.1	50-sn-117m	5.73E-07	5.89892E-07	1.22E-06	1.17032E-06
117	50-sn-117	0.00E+00	0.00000E+00		0.00000E+00
118	44-ru-118	6.93E+01	1.04650E+00		4.80669E-06
118	45-rh-118	4.62E-01	2.19594E+00		9.01776E-06
118	46-pd-118	1.54E-01	2.23596E-01		3.41693E-06
118.1	47-ag-118m	2.77E-02	3.46574E-01		6.80251E-06
118	48-cd-118	2.31E-04	2.29671E-04		1.60920E-07
118.1	49-in-118m1	2.57E-03	2.59606E-03	1.16E-06	1.25392E-05
118	49-in-118	1.39E-01	1.38629E-01		3.51097E-07
118	50-sn-118	0.00E+00	0.00000E+00		0.00000E+00
119	44-ru-119	6.93E+01	3.55551E+00		8.63114E-06
119	45-rh-119	4.62E-01	1.48929E+00		6.16510E-06
119	46-pd-119	2.31E-01	3.94125E-01		5.35005E-06
119	47-ag-119	4.08E-02	3.30070E-01		7.73250E-06
119	48-cd-119	4.28E-03	4.29459E-03		7.28318E-06
119.1	48-cd-119m	1.22E-03	5.25112E-03		1.02612E-05
119.1	49-in-119m	6.42E-04	6.41803E-04	2.69E-07	7.38767E-07
119	49-in-119	5.78E-03	4.81352E-03	4.07E-06	3.85580E-06
119.1	50-sn-119m	3.27E-08	2.73807E-08	1.47E-07	2.78997E-07
119	50-sn-119	0.00E+00	0.00000E+00		0.00000E+00
120	45-rh-120	6.93E+01	4.01918E+00		1.00418E-05
120	46-pd-120	3.47E-01	1.77434E-01		3.71996E-06
120	47-ag-120	1.16E-01	5.92433E-01		1.07628E-05
120	48-cd-120	9.63E-04	1.36446E-02	2.71E-06	6.62487E-07
120.1	49-in-120m1	1.39E-02	1.50032E-02		1.26437E-05
120	50-sn-120	0.00E+00	0.00000E+00		0.00000E+00

Table A-11. DELFIC original and upgrade decay constants and exposure rate multipliers, 121 ≤ Mass No. ≤ 125.

At. Wt.	Nuclide	Decay Constant (sec^{-1}) Original	Upgrade	ERM ($R/hr/KT/m^2$) Original	Upgrade
121	45-rh-121	6.93E+01	2.77748E+00		6.98015E-06
121	46-pd-121	4.62E-01	1.07687E+00		6.38454E-06
121	47-ag-121	1.73E-01	8.66434E-01		3.36991E-06
121	48-cd-121	6.93E-02	5.13442E-02		8.27586E-06
121.1	49-in-121m	3.73E-03	2.97744E-03	4.69E-06	4.97388E-07
121	49-in-121	2.31E-02	3.00064E-02		4.57680E-06
121.1	50-sn-121m	8.79E-10	3.99363E-10		1.12853E-07
121	50-sn-121	7.13E-06	7.11533E-06		0.00000E+00
121	51-sb-121	0.00E+00	0.00000E+00		0.00000E+00
122	46-pd-122	4.62E-01	4.91176E-01		4.08568E-06
122.1	47-ag-122m	2.31E-01	4.62098E-01		1.03239E-05
122	48-cd-122	1.73E-02	1.32280E-01		2.26750E-06
122.1	49-in-122m1	1.54E-02	6.72958E-02		1.12853E-05
122	50-sn-122	0.00E+00	0.00000E+00		0.00000E+00
122.1	51-sb-122m	2.78E-03	2.74405E-03	4.84E-07	8.10867E-07
122	51-sb-122	2.87E-06	2.97131E-06	2.02E-06	2.25705E-06
122	52-te-122	0.00E+00	0.00000E+00		0.00000E+00
123	46-pd-123	6.93E+01	2.30734E+00		7.03239E-06
123	47-ag-123	2.77E-01	1.77730E+00		7.29363E-06
123	48-cd-123	7.70E-02	7.78380E-02		4.59770E-06
123.1	49-in-123m	1.93E-02	1.45010E-02	5.35E-06	3.54232E-07
123	49-in-123	6.93E-02	1.15911E-01		4.97388E-06
123	50-sn-123	6.42E-08	6.20939E-08	1.05E-07	3.09300E-08
123.1	50-sn-123m	2.82E-04	2.88235E-04	8.32E-07	7.95193E-07
123	51-sb-123	0.00E+00	0.00000E+00		0.00000E+00
124	46-pd-124	6.93E+01	1.34859E+00		4.54545E-06
124	47-ag-124	3.47E-01	2.77837E+00		9.32079E-06
124	48-cd-124	6.93E-02	7.70164E-01		2.72727E-06
124.1	49-in-124m	3.47E-02	2.88811E-01		1.75549E-05
124	50-sn-124	0.00E+00	0.00000E+00		0.00000E+00
124.2	51-sb-124m2	5.50E-04	5.71904E-04	8.96E-06	2.04807E-11
124.1	51-sb-124m1	8.89E-03	7.45320E-03		2.28840E-06
124	51-sb-124	1.34E-07	1.33265E-07		8.36991E-06
124	52-te-124	0.00E+00	0.00000E+00		0.00000E+00
125	47-ag-125	3.47E-01	2.07834E+00		6.83386E-06
125	48-cd-125	1.39E-01	4.47769E-01		5.40230E-06
125.1	49-in-125m	4.62E-02	5.68153E-02		3.05120E-06
125.1	50-sn-125m	1.19E-03	1.21349E-03	1.96E-06	1.89133E-06
125	50-sn-125	8.53E-07	8.32213E-07	3.98E-07	1.41066E-06
125	51-sb-125	8.13E-09	8.04578E-09	2.54E-06	2.50784E-06
125.1	52-te-125m	1.38E-07	1.38330E-07	3.27E-07	7.55486E-07
125	52-te-125	0.00E+00	0.00000E+00		0.00000E+00

Table A-12. DELFIC original and upgrade decay constants and exposure rate multipliers, 126 ≤ Mass No. ≤ 130.

At. Wt.	Nuclide	Decay Constant (sec^{-1}) Original	Upgrade	ERM ($R/hr/KT/m^2$) Original	Upgrade
126	47-ag-126	6.93E+01	4.95672E+00		1.18077E-05
126	48-cd-126	2.31E-01	1.36986E+00		3.29154E-06
126.1	49-in-126m	9.90E-02	4.62098E-01		1.06583E-05
126	50-sn-126	1.10E-13	2.19650E-13		8.98642E-07
126.1	51-sb-126m1	6.08E-04	6.08024E-04	9.39E-06	8.09822E-06
126	51-sb-126	6.42E-07	6.46979E-07		1.41066E-05
126	52-te-126	0.00E+00	0.00000E+00		0.00000E+00
127	47-ag-127	6.93E+01	3.95474E+00		7.93103E-06
127	48-cd-127	4.62E-01	1.21207E+00		7.72205E-06
127.1	49-in-127m	2.31E-01	1.84348E-01		7.14734E-06
127	50-sn-127	8.56E-05	9.16861E-05		8.46395E-06
127.1	50-sn-127m	2.75E-03	2.79720E-03	2.71E-06	4.40961E-06
127	51-sb-127	2.06E-06	2.08378E-06	2.63E-06	3.42738E-06
127.1	52-te-127m	7.64E-08	7.36013E-08	5.14E-07	2.35110E-07
127	52-te-127	2.07E-05	2.05926E-05	2.34E-08	2.67503E-08
127	53-i-127	0.00E+00	0.00000E+00		0.00000E+00
128	48-cd-128	6.93E-01	6.58197E-01		4.37827E-06
128	49-in-128	3.47E-01	7.70164E-01		1.12853E-05
128	50-sn-128	2.03E-04	1.95473E-04	2.39E-06	3.90805E-06
128.1	51-sb-128m	1.05E-03	1.11081E-03	9.28E-06	9.43574E-06
128	51-sb-128	2.24E-05	2.13697E-05		1.54650E-05
128	52-te-128	0.00E+00	0.00000E+00		0.00000E+00
128	53-i-128	4.62E-04	4.62283E-04	4.90E-07	5.05747E-07
128	54-xe-128	0.00E+00	0.00000E+00		0.00000E+00
129	48-cd-129	6.93E+01	2.32039E+00		8.35946E-06
129	49-in-129	4.62E-01	1.17483E+00		8.76698E-06
129	50-sn-129	1.07E-04	5.34836E-03		7.00104E-06
129	51-sb-129	4.19E-05	4.37593E-05	5.40E-06	6.45768E-06
129.1	52-te-129m	1.96E-07	2.38766E-07	1.83E-07	3.22884E-07
129	52-te-129	1.60E-04	1.65984E-04	1.25E-06	4.08568E-07
129	53-i-129	1.37E-15	1.39904E-15		5.09927E-07
129.1	54-xe-129m	1.00E-06	9.02423E-07	4.30E-07	9.32079E-07
129	54-xe-129	0.00E+00	0.00000E+00		0.00000E+00
130	48-cd-130	6.93E+01	1.45390E+00		5.15152E-06
130	49-in-130	4.62E-01	2.16608E+00		1.41066E-05
130	50-sn-130	4.44E-03	3.10550E-03		5.12017E-06
130.1	51-sb-130m	1.93E-03	1.83372E-03		1.30617E-05
130	51-sb-130	3.12E-04	2.92467E-04		1.60920E-05
130	52-te-130	0.00E+00	0.00000E+00		0.00000E+00
130	53-i-130	1.54E-05	1.55777E-05	7.84E-06	1.08673E-05
130	54-xe-130	0.00E+00	0.00000E+00		0.00000E+00

Table A-13. DELFIC original and upgrade decay constants and exposure rate multipliers, 131 ≤ Mass No. ≤ 135.

At. Wt.	Nuclide	Decay Constant (sec^{-1}) Original	Upgrade	ERM ($R/hr/KT/m^2$) Original	Upgrade
131	48-cd-131	6.93E+01	6.52865E+00		1.14943E-05
131	49-in-131	6.93E-01	2.56721E+00		7.47126E-06
131.1	50-sn-131m	1.05E-02	1.13259E-02		8.32811E-06
131	51-sb-131	5.95E-04	5.02281E-04	3.18E-06	8.01463E-06
131.1	52-te-131m	6.42E-06	6.41803E-06	9.30E-06	6.90700E-06
131	52-te-131	4.81E-04	4.62098E-04	2.13E-06	2.16301E-06
131	53-i-131	9.97E-07	9.97828E-07	2.21E-06	2.05852E-06
131.1	54-xe-131m	6.69E-07	6.74163E-07	1.98E-07	3.86625E-07
131	54-xe-131	0.00E+00	0.00000E+00		0.00000E+00
132	48-cd-132	6.93E+01	5.10719E+00		7.34587E-06
132	49-in-132	6.93E+01	3.72660E+00		1.95402E-05
132	50-sn-132	1.39E-02	1.73287E-02		6.60397E-06
132.1	51-sb-132m	3.69E-03	4.12588E-03		1.26437E-05
132	52-te-132	2.47E-06	2.46216E-06	1.44E-06	1.57785E-06
132	53-i-132	8.37E-05	8.42999E-05	1.12E-05	1.12853E-05
132	54-xe-132	0.00E+00	0.00000E+00		0.00000E+00
133	49-in-133	6.93E+01	6.20933E+00		1.19122E-05
133	50-sn-133	1.78E-02	4.81352E-01		7.89969E-06
133	51-sb-133	4.38E-03	4.62098E-03		8.78788E-06
133.1	52-te-133m	2.31E-04	2.08528E-04	1.12E-05	8.08777E-06
133	52-te-133	9.24E-04	9.24196E-04	7.84E-06	5.62173E-06
133	53-i-133	9.26E-06	9.25677E-06	3.14E-06	3.11390E-06
133.1	54-xe-133m	3.49E-06	3.66326E-06	3.84E-07	4.96343E-07
133	54-xe-133	1.52E-06	1.53014E-06	3.06E-07	3.32288E-07
133	55-cs-133	0.00E+00	0.00000E+00		0.00000E+00
134	49-in-134	6.93E+01	8.60443E+00		1.54650E-05
134	50-sn-134	6.93E+01	6.66488E-01		5.46499E-06
134	51-sb-134	4.62E-01	8.15467E-01		8.21317E-06
134	52-te-134	2.75E-04	2.76374E-04	6.84E-06	4.50366E-06
134	53-i-134	2.18E-04	2.19628E-04	1.22E-05	1.25392E-05
134	54-xe-134	0.00E+00	2.39016E+00		9.47753E-06
134.1	55-cs-134m	6.64E-05	6.61653E-05	7.54E-07	1.98537E-07
134	55-cs-134	9.98E-09	1.06523E-08	8.13E-06	7.80564E-06
134	56-ba-134	0.00E+00	0.00000E+00		0.00000E+00
135	50-sn-135	6.93E+01	1.65916E+00		9.60293E-06
135	51-sb-135	3.65E-01	4.05349E-01		6.24869E-06
135	52-te-135	8.25E-03	3.64814E-02		6.21735E-06
135	53-i-135	2.87E-05	2.93061E-05	1.56E-05	7.04284E-06
135.1	54-xe-135m	7.55E-04	7.55556E-04	2.39E-06	2.28840E-06
135	54-xe-135	2.09E-05	2.10657E-05	1.49E-06	1.31661E-06
135	55-cs-135	1.10E-14	9.54999E-15		0.00000E+00
135	56-ba-135	0.00E+00	0.00000E+00		0.00000E+00

Table A-14. DELFIC original and upgrade decay constants and exposure rate multipliers, 136 ≤ Mass No. ≤ 141.

At. Wt.	Nuclide	Decay Constant (sec^{-1}) Original	Upgrade	ERM ($R/hr/KT/m^2$) Original	Upgrade
136	51-sb-136	2.31E-01	8.45301E-01		9.56113E-06
136	52-te-136	1.16E-01	3.96084E-02		7.82654E-06
136	53-i-136	8.35E-03	8.31112E-03	1.21E-05	9.71787E-06
136	54-xe-136	0.00E+00	0.00000E+00		0.00000E+00
136	55-cs-136	6.17E-07	6.09617E-07	1.17E-05	9.12226E-06
136	56-ba-136	0.00E+00	0.00000E+00		0.00000E+00
137	51-sb-137	6.93E+01	1.45055E+00		9.31034E-06
137	52-te-137	2.31E-01	1.98042E-01		6.56217E-06
137	53-i-137	2.84E-02	2.82917E-02		4.53501E-06
137	54-xe-137	2.96E-03	3.02579E-03		9.42529E-07
137	55-cs-137	7.52E-10	7.32166E-10		0.00000E+00
137.1	56-ba-137m	4.44E-03	4.52682E-03	3.18E-06	3.11390E-06
137	56-ba-137	0.00E+00	0.00000E+00		0.00000E+00
138	51-sb-138	6.93E+01	3.99831E+00		1.28527E-05
138	52-te-138	3.47E-01	4.95105E-01		4.93208E-06
138	53-i-138	1.10E-01	1.06802E-01		1.03971E-05
138	54-xe-138	8.25E-04	8.20487E-04	4.41E-06	4.80669E-06
138	55-cs-138	3.59E-04	3.58772E-04	9.79E-06	1.03135E-05
138	56-ba-138	0.00E+00	0.00000E+00		0.00000E+00
138	57-la-138	1.00E-15	2.09190E-19		5.75758E-06
138	58-ce-138	0.00E+00	0.00000E+00		0.00000E+00
139	52-te-139	6.93E+01	1.19504E+00		9.24765E-06
139	53-i-139	3.47E-01	3.01368E-01		5.60084E-06
139	54-xe-139	1.69E-02	1.74684E-02	1.46E-06	4.06479E-06
139	55-cs-139	1.22E-03	1.24622E-03	1.10E-06	1.36886E-06
139	56-ba-139	1.36E-04	1.36505E-04	2.55E-07	2.33020E-07
139	57-la-139	0.00E+00	0.00000E+00		0.00000E+00
140	52-te-140	6.93E+01	7.75471E-01		5.60084E-06
140	53-i-140	4.62E-01	8.05985E-01		8.72518E-06
140	54-xe-140	4.33E-02	5.09667E-02		7.02194E-06
140	55-cs-140	1.05E-02	1.08814E-02	3.23E-06	9.07001E-06
140	56-ba-140	6.27E-07	6.29121E-07	1.16E-06	1.04389E-06
140	57-la-140	4.79E-06	4.78072E-06	1.14E-05	9.98955E-06
140	58-ce-140	0.00E+00	0.00000E+00		0.00000E+00
141	53-i-141	6.93E+01	1.50684E+00		7.02194E-06
141	54-xe-141	4.08E-01	4.00663E-01		6.73981E-06
141	55-cs-141	2.77E-02	2.77926E-02		4.95298E-06
141	56-ba-141	6.42E-04	6.32318E-04	3.65E-06	4.02299E-06
141	57-la-141	5.07E-05	4.91176E-05	1.27E-07	1.97492E-07
141	58-ce-141	2.43E-07	2.46839E-07	4.67E-07	4.29467E-07
141	59-pr-141	0.00E+00	0.00000E+00		0.00000E+00

Table A-15. DELFIC original and upgrade decay constants and exposure rate multipliers, 142 ≤ Mass No. ≤ 146.

At. Wt.	Nuclide	Decay Constant (sec^{-1}) Original	Upgrade	ERM ($R/hr/KT/m^2$) Original	Upgrade
142	53-i-142	6.93E+01	3.46574E+00		1.17032E-05
142	54-xe-142	4.62E-01	5.68153E-01		7.17868E-06
142	55-cs-142	8.66E-02	4.07734E-01		7.23093E-06
142	56-ba-142	1.16E-03	1.08985E-03	4.95E-06	5.16196E-06
142	57-la-142	1.38E-04	1.26811E-04	6.01E-06	9.46709E-06
142	58-ce-142	0.00E+00	0.00000E+00		0.00000E+00
143	53-i-143	6.93E+01	1.72816E+00		8.81923E-06
143	54-xe-143	6.93E-01	7.22028E-01		8.23406E-06
143	55-cs-143	3.47E-01	3.89409E-01		5.63218E-06
143	56-ba-143	5.33E-02	4.78033E-02		4.70219E-06
143	57-la-143	6.42E-04	8.17005E-04	5.74E-06	1.14943E-06
143	58-ce-143	5.83E-06	5.83457E-06	3.50E-06	1.57785E-06
143	59-pr-143	5.81E-07	5.91196E-07		4.37827E-14
143	60-nd-143	0.00E+00	0.00000E+00		0.00000E+00
144	54-xe-144	6.93E+01	6.30134E-01		4.15883E-06
144	55-cs-144	4.62E-01	6.79556E-01		1.00731E-05
144	56-ba-144	1.98E-01	6.08024E-02		3.82445E-06
144	57-la-144	4.62E-02	1.69474E-02		1.00627E-05
144	58-ce-144	2.81E-08	2.81591E-08	1.23E-07	1.15987E-07
144	59-pr-144	6.68E-04	6.68545E-04	1.40E-07	1.25392E-07
144	60-nd-144	0.00E+00	0.00000E+00		0.00000E+00
145	54-xe-145	6.93E+01	7.70164E-01		7.08464E-06
145	55-cs-145	6.93E-01	1.16691E+00		1.03553E-05
145	56-ba-145	3.47E-01	1.60823E-01		4.30512E-06
145	57-la-145	7.70E-02	2.79495E-02		6.84431E-06
145	58-ce-145	3.85E-03	3.83802E-03	3.65E-06	4.31557E-06
145	59-pr-145	3.22E-05	3.21759E-05	4.09E-06	9.25720E-08
145	60-nd-145	0.00E+00	0.00000E+00		0.00000E+00
146	54-xe-146	6.93E+01	1.23187E+00		4.67085E-06
146	55-cs-146	6.93E+01	2.02084E+00		8.78788E-06
146	56-ba-146	4.62E-01	3.15067E-01		4.08568E-06
146	57-la-146	1.73E-01	1.10550E-01		9.48798E-06
146	58-ce-146	8.31E-04	8.54471E-04	1.50E-06	1.72414E-06
146	59-pr-146	4.73E-04	4.78362E-04	6.53E-06	4.55590E-06
146	60-nd-146	0.00E+00	0.00000E+00		0.00000E+00

Table A-16. DELFIC original and upgrade decay constants and exposure rate multipliers, 147 ≤ Mass No. ≤ 151.

At. Wt.	Nuclide	Decay Constant (sec^{-1}) Original	Upgrade	ERM ($R/hr/KT/m^2$) Original	Upgrade
147	55-cs-147	6.93E+01	1.27071E+00		6.25914E-06
147	56-ba-147	6.93E-01	9.90210E-01		5.35005E-06
147	57-la-147	3.47E-01	1.57533E-01		4.32602E-06
147	58-ce-147	9.63E-03	1.22898E-02		5.22466E-06
147	59-pr-147	9.63E-04	8.49445E-04		4.36782E-06
147	60-nd-147	7.23E-07	7.30650E-07	9.60E-07	8.31766E-07
147	61-pm-147	8.45E-09	8.37272E-09		2.67503E-11
147	62-sm-147	0.00E+00	2.07217E-19		0.00000E+00
148	55-cs-148	6.93E+01	3.37134E+00		1.08673E-05
148	56-ba-148	6.93E-01	1.14192E+00		4.10658E-06
148	57-la-148	3.47E-01	6.60140E-01		5.68443E-06
148	58-ce-148	1.73E-02	1.23776E-02		1.73459E-06
148	59-pr-148	5.92E-03	5.08919E-03		5.50679E-06
148	60-nd-148	0.00E+00	0.00000E+00		0.00000E+00
148	61-pm-148	1.49E-06	1.49395E-06	5.28E-06	2.71682E-06
148	62-sm-148	0.00E+00	0.00000E+00		0.00000E+00
149	56-ba-149	6.93E+01	9.97076E-01		6.07106E-06
149	57-la-149	4.62E-01	2.87864E-01		4.53501E-06
149	58-ce-149	1.98E-01	1.33298E-01		4.75444E-06
149	59-pr-149	2.31E-02	5.11170E-03		3.18704E-06
149	60-nd-149	9.63E-05	1.11618E-04	1.22E-06	2.00627E-06
149	61-pm-149	3.63E-06	3.62737E-06	2.80E-08	6.21735E-08
149	62-sm-149	0.00E+00	0.00000E+00		0.00000E+00
150	56-ba-150	6.93E+01	7.20385E-01		4.83804E-06
150	57-la-150	4.62E-01	1.13989E+00		9.74922E-06
150	58-ce-150	2.77E-01	1.73287E-01		2.19436E-06
150	59-pr-150	4.62E-02	1.11979E-01		4.33647E-06
150	60-nd-150	0.00E+00	0.00000E+00		0.00000E+00
150	61-pm-150	7.13E-05	7.18436E-05	8.08E-06	6.82341E-06
150	62-sm-150	0.00E+00	0.00000E+00		0.00000E+00
151	57-la-151	6.93E-01	9.63521E-01		6.37409E-06
151	58-ce-151	3.47E-01	6.79556E-01		3.76176E-06
151	59-pr-151	9.90E-02	3.66745E-02		3.47962E-06
151	60-nd-151	8.89E-04	9.28654E-04	5.60E-06	4.58725E-06
151	61-pm-151	6.78E-06	6.77961E-06	1.29E-06	1.77638E-06
151	62-sm-151	2.75E-10	2.44056E-10		1.64054E-10
151	63-eu-151	0.00E+00	0.00000E+00		0.00000E+00

Table A-17. DELFIC original and upgrade decay constants and exposure rate multipliers, 152 ≤ Mass No. ≤ 156.

At. Wt.	Nuclide	Decay Constant (sec^{-1}) Original	Upgrade	ERM ($R/hr/KT/m^2$) Original	Upgrade
152	57-la-152	6.93E+01	2.43252E+00		1.07628E-05
152	58-ce-152	4.62E-01	9.04573E-02		3.68861E-06
152	59-pr-152	1.39E-01	1.02293E-01		8.40125E-06
152	60-nd-152	3.85E-03	1.01337E-03		9.20585E-07
152	61-pm-152	1.93E-03	2.81767E-03	3.40E-06	7.37722E-07
152	62-sm-152	0.00E+00	0.00000E+00		0.00000E+00
152.1	63-eu-152m1	2.07E-05	2.06589E-05	1.92E-06	1.54650E-06
152	63-eu-152	1.69E-09	1.64778E-09	5.80E-06	5.66353E-06
152	64-gd-152	0.00E+00	0.00000E+00		0.00000E+00
153	57-la-153	6.93E+01	2.12726E+00		8.06688E-06
153	58-ce-153	4.62E-01	4.71914E-01		4.62905E-06
153	59-pr-153	2.31E-01	1.54352E-01		4.29467E-06
153	60-nd-153	3.85E-02	1.02688E-02		3.20794E-06
153	61-pm-153	2.10E-03	2.13934E-03	8.04E-07	8.93417E-07
153	62-sm-153	4.10E-06	4.16125E-06	1.86E-07	4.68130E-07
153	63-eu-153	0.00E+00	0.00000E+00		0.00000E+00
154	58-ce-154	6.93E-01	3.43806E-01		4.35737E-06
154	59-pr-154	3.47E-01	6.53050E-01		9.36259E-06
154	60-nd-154	5.78E-02	1.73287E-02		3.06165E-06
154	61-pm-154		6.71654E-03		7.97283E-06
154	62-sm-154	0.00E+00	0.00000E+00		0.00000E+00
154	63-eu-154	1.37E-09	2.55645E-09	6.01E-06	5.93521E-06
154	64-gd-154	0.00E+00	0.00000E+00		0.00000E+00
155	58-ce-155	6.93E+01	1.31323E+00		6.22780E-06
155	59-pr-155	3.47E-01	6.17558E-01		5.95611E-06
155	60-nd-155	1.39E-01	3.80411E-02		3.67816E-06
155	61-pm-155	1.16E-02	1.44406E-02		3.10345E-06
155	62-sm-155	4.81E-04	5.18047E-04	7.26E-07	5.66353E-07
155	63-eu-155	1.29E-08	4.69338E-09	2.89E-07	3.82445E-07
155	64-gd-155	0.00E+00	0.00000E+00		0.00000E+00
156	59-pr-156	4.62E-01	1.82763E+00		1.00836E-05
156	60-nd-156	1.54E-01	3.53250E-02		3.68861E-06
156	61-pm-156	2.77E-02	5.29120E-02		7.70115E-06
156	62-sm-156	1.93E-05	2.04831E-05		6.35319E-07
156	63-eu-156	5.21E-07	5.28144E-07	3.02E-06	5.40230E-06
156	64-gd-156	0.00E+00	0.00000E+00		0.00000E+00

Table A-18. DELFIC original and upgrade decay constants and exposure rate multipliers, 157 ≤ Mass No. ≤ 161.

At. Wt.	Nuclide	Decay Constant (sec^{-1}) Original	Upgrade	ERM ($R/hr/KT/m^2$) Original	Upgrade
.57	59-pr-157	6.93E+01	1.82402E+00		7.27273E-06
157	60-nd-157	2.31E-01	2.79123E-01		4.74399E-06
157	61-pm-157	5.33E-02	1.13291E-02		3.79310E-06
157	62-sm-157	2.31E-02	1.43153E-03		2.01672E-06
157	63-eu-157	1.28E-05	1.26839E-05	3.38E-06	1.52560E-06
157	64-gd-157	0.00E+00	0.00000E+00		0.00000E+00
158	59-pr-158	6.93E+01	4.11241E+00		1.13898E-05
158	60-nd-158	3.47E-01	2.57207E-01		4.20063E-06
158	61-pm-158	1.16E-01	1.82422E-01		8.64159E-06
158	62-sm-158	7.70E-04	2.09663E-03	2.71E-06	2.87356E-06
158	63-eu-158	1.93E-04	2.51687E-04	6.30E-06	5.09927E-06
158	64-gd-158	0.00E+00	0.00000E+00		0.00000E+00
159	60-nd-159	4.62E-01	1.08036E+00		6.61442E-06
159	61-pm-159	1.98E-01	2.31011E-01		4.82759E-06
159	62-sm-159	4.95E-02	4.27869E-03		4.39916E-06
159	63-eu-159	5.78E-04	6.38257E-04		2.10031E-06
159	64-gd-159	1.07E-05	1.03740E-05	3.95E-07	3.20794E-07
159	65-tb-159	0.00E+00	0.00000E+00		0.00000E+00
160	60-nd-160	6.93E+01	8.79004E-01		5.22466E-06
160	61-pm-160	2.77E-01	9.50924E-01		9.66562E-06
160	62-sm-160	4.62E-02	9.55024E-03		3.35423E-06
160	63-eu-160	4.62E-03	1.57533E-02		7.94148E-06
160	64-gd-160	0.00E+00	0.00000E+00		0.00000E+00
160	65-tb-160	1.10E-07	1.10962E-07	2.02E-06	5.89342E-06
160	66-dy-160	0.00E+00	0.00000E+00		0.00000E+00
161	60-nd-161	6.93E+01	2.22655E+00		7.33542E-06
161	61-pm-161	3.47E-01	8.77479E-01		6.81296E-06
161	62-sm-161	1.73E-01	1.45007E-01		4.79624E-06
161	63-eu-161	3.15E-02	1.64839E-02		4.51411E-06
161	64-gd-161	3.12E-03	3.15641E-03	2.03E-06	2.17346E-06
161	65-tb-161	1.16E-06	1.16269E-06	2.43E-07	3.16614E-07
161	66-dy-161	0.00E+00	0.00000E+00		0.00000E+00

APPENDIX B
FISSION PRODUCTS NOT IN DELFIC

This appendix contains a list of fission products for which decay rates and gamma ray emission rates are available but which are not included in the DELFIC inventory.

Table B-1. Fission products not in DELFIC for which decay constants and exposure rate multipliers are available, 31 ≤ Atomic No. ≤ 44.

At. Wt.	Nuclide	Decay Constant (sec^{-1})	ERM ($R/hr/KT/m^2$)
74.1	31-ga-74m	7.29629E-02	2.67503E-07
79.1	32-ge-79m	1.77730E-02	8.40125E-06
82.1	33-as-82m	5.09667E-02	1.26437E-05
84.1	33-as-84m	1.15525E+00	1.22257E-05
75	34-se-75	6.69830E-08	2.37200E-06
77.1	34-se-77m	3.97219E-02	5.94566E-07
79.1	35-br-79m	1.42623E-01	9.11181E-07
80	35-br-80	6.53419E-04	4.08568E-07
80.1	35-br-80m	4.35613E-05	7.12644E-07
82.1	35-br-82m	1.88458E-03	3.16614E-07
84.1	35-br-84m	1.92541E-03	1.31661E-05
79	36-kr-79	5.49489E-06	1.66144E-06
79.1	36-kr-79m	1.38629E-02	4.47231E-07
81	36-kr-81	1.03122E-13	4.24242E-07
81.1	36-kr-81m	5.33190E-02	7.97283E-07
90.1	37-rb-90m	2.68662E-03	1.32706E-05
100	37-rb-100	7.04146E+00	1.56740E-05
101	37-rb-101	7.38561E+00	1.10763E-05
85	38-sr-85	1.23728E-07	3.11390E-06
85.1	38-sr-85m	1.70743E-04	1.20167E-06
87.1	38-sr-87m	6.85199E-05	1.79728E-06
103	38-sr-103	5.79554E+00	1.06583E-05
104	38-sr-104	4.25452E+00	7.35632E-06
90.1	39-y-90m	6.03576E-05	3.35423E-06
93.1	39-y-93m	8.45301E-01	3.75131E-06
96	39-y-96	1.17483E-01	4.59770E-06
97	39-y-97	1.98042E-01	6.33229E-06
98	39-y-98	1.08304E+00	9.71787E-06
107	39-y-107	7.51322E+00	1.00104E-05
90.1	40-zr-90m	8.56583E-01	8.78788E-06
94	41-nb-94	1.08202E-12	7.72205E-06
94.1	41-nb-94m	1.84544E-03	4.43051E-07
99	41-nb-99	4.62098E-02	3.92894E-06
100.1	41-nb-100m	2.32600E-01	9.71787E-06
102	41-nb-102	5.33190E-01	5.53814E-06
104.1	41-nb-104m	6.93147E-01	7.98328E-06
112	41-nb-112	7.99303E+00	1.44201E-05
93	42-mo-93	6.27572E-12	6.33229E-07
115	42-mo-115	5.50510E+00	1.09716E-05
97	43-tc-97	8.44807E-15	7.56531E-07
97.1	43-tc-97m	8.86468E-08	4.69175E-07
118	43-tc-118	8.49924E+00	1.30617E-05
97	44-ru-97	2.76639E-06	1.88088E-06
109	44-ru-109	1.98042E-02	4.58725E-06
120	44-ru-120	1.97884E+00	5.29781E-06

Table B-2. Fission products not in DELFIC for which decay constants and exposure rate multipliers are available, 45 ≤ Atomic No. ≤ 49.

At Wt.	Nuclide	Decay Constant (sec^{-1})	ERM ($R/hr/KT/m^2$)
108.1	45-rh-108m	1.92541E-03	1.36806E-05
110.1	45-rh-110m	2.43210E-02	1.26437E-05
122	45-rh-122	6.46894E+00	1.05538E-05
123	45-rh-123	5.16157E+00	7.81609E-06
103	46-pd-103	4.72165E-07	3.62591E-07
107.1	46-pd-107m	3.25421E-02	8.81923E-07
125	46-pd-125	4.17458E+00	7.68025E-06
126	46-pd-126	2.75037E+00	5.20376E-06
107.1	47-ag-107m	1.56467E-02	2.24660E-07
108	47-ag-108	4.87445E-03	1.03762E-07
108.1	47-ag-108m	1.72953E-10	8.57889E-06
110	47-ag-110	2.81767E-02	1.58830E-07
110.1	47-ag-110m	3.21209E-08	1.33751E-05
116	47-ag-116	4.31062E-03	8.87147E-06
117.1	47-ag-117m	1.29803E-01	4.33647E-06
118	47-ag-118	1.84348E-01	6.21735E-06
120.1	47-ag-120m	2.16608E+00	7.75340E-06
122	47-ag-122	1.44406E+00	1.07628E-05
128	47-ag-128	7.35208E+00	1.23302E-05
107	48-cd-107	2.96217E-05	4.34692E-07
109	48-cd-109	1.73423E-08	3.75131E-07
111.1	48-cd-111m	2.37705E-04	1.67189E-06
113.1	48-cd-113	1.55780E-09	5.70533E-10
121.1	48-cd-121m	1.44406E-01	1.02508E-05
113.1	49-in-113m	1.16128E-04	1.49425E-06
114	49-in-114	9.64043E-03	1.25392E-08
114.1	49-in-114m	1.62039E-07	6.61442E-07
116	49-in-116	4.91594E-02	8.85057E-08
116.1	49-in-116m1	2.13342E-04	1.09718E-05
116.2	49-in-116m2	3.17957E-01	5.20376E-07
118.2	49-in-118m2	8.15467E-02	5.53814E-07
120	49-in-120	2.25048E-01	2.67503E-06
120.2	49-in-120m2	1.46543E-02	1.55695E-05
122	49-in-122	4.62098E-01	4.98433E-06
122.2	49-in-122m2	6.41803E-02	1.56740E-05
124	49-in-124	2.18658E-01	1.06583E-05
125	49-in-125	2.97488E-01	5.89342E-06
126	49-in-126	4.78033E-01	1.96447E-05
127	49-in-127	6.02737E-01	7.60711E-06
128.1	49-in-128m	7.70164E-01	1.41066E-05
129.1	49-in-129m	5.50117E-01	1.18077E-05
130.1	49-in-130m1	1.26027E+00	8.70428E-06
130.2	49-in-130m2	1.26027E+00	1.35841E-05
131.1	49-in-131m	1.98042E+00	0.00000E+00

Table B-3. Fission products not in DELFIC for which decay constants and exposure rate multipliers are available, 50 ≤ Atomic No. ≤ 58.

At. Wt.	Nuclide	Decay Constant (sec^{-1})	ERM ($R/hr/KT/m^2$)
113	50-sn-113	6.97066E-08	4.78579E-07
113.1	50-sn-113m	5.39834E-04	3.33333E-07
128.1	50-sn-128m	1.06638E-01	9.55068E-06
129.1	50-sn-129m	1.72425E-03	9.75967E-06
130.1	50-sn-130m	6.79556E-03	5.38140E-06
131	50-sn-131	1.77730E-02	1.03762E-05
136	50-sn-136	9.66490E-01	6.21735E-06
126.2	51-sb-126m2	6.30134E-02	7.72205E-10
132	51-sb-132	2.75058E-03	1.27482E-05
134.1	51-sb-134m	6.64571E-02	1.09718E-05
139	51-sb-139	3.18235E+00	1.01149E-05
121	52-te-121	4.78102E-07	3.39603E-06
121.1	52-te-121m	5.20944E-08	1.36886E-06
123	52-te-123	1.77137E-21	3.20794E-07
123.1	52-te-123m	6.70219E-08	1.01463E-06
141	52-te-141	2.54254E+00	9.94775E-06
142	52-te-142	1.17469E+00	5.97701E-06
125	53-i-125	1.33398E-07	9.07001E-07
130.1	53-i-130m	1.28361E-03	6.44723E-07
132.1	53-i-132m	1.38187E-04	1.75549E-06
133.1	53-i-133m	7.70164E-02	8.26541E-06
134.1	53-i-134m	3.13075E-03	1.66144E-06
136.1	53-i-136m	1.47793E-02	1.20167E-05
144	53-i-144	4.74856E+00	1.17032E-05
145	53-i-145	3.58364E+00	8.85057E-06
125	54-xe-125	1.13930E-05	1.90178E-06
125.1	54-xe-125	1.21605E-02	9.15361E-07
127	54-xe-127	2.20399E-07	1.92268E-06
127.1	54-xe-127	1.00166E-02	1.14943E-06
143.1	54-xe-143m	2.31049E+00	6.81296E-06
147	54-xe-147	3.48158E+00	8.74608E-06
135.1	55-cs-135m	2.17971E-04	7.84744E-06
138.1	55-cs-138m	3.96992E-03	3.19749E-06
149	55-cs-149	2.83856E+00	9.17450E-06
150	55-cs-150	5.60074E+00	1.19122E-05
135.1	56-ba-135m	6.70874E-06	4.12748E-07
136.1	56-ba-136m	2.24756E+00	9.10136E-06
151	56-ba-151	2.08315E+00	8.74608E-06
152	56-ba-152	1.64843E+00	5.91432E-06
146.1	57-la-146m	6.93147E-02	7.41902E-06
154	57-la-154	4.64389E+00	1.14943E-05
155	57-la-155	4.50125E+00	1.00627E-05
156	58-ce-156	1.16243E+00	5.05747E-06
157	58-ce-157	3.23266E+00	7.97283E-06

Table B-4. Fission products not in DELFIC for which decay constants and exposure rate multipliers are available, 59 ≤ Atomic No. ≤ 68.

At. Wt.	Nuclide	Decay Constant (sec^{-1})	ERM ($R/hr/KT/m^2$)
142	59-pr-142	1.00701E-05	2.39289E-07
142.1	59-pr-142m	7.91264E-04	0.00000E+00
144.1	59-pr-144m	1.60451E-03	1.29572E-07
148.1	59-pr-148m	5.77623E-03	8.29676E-06
159	59-pr-159	3.83909E+00	8.76698E-06
145	61-pm-145	1.24096E-09	3.40648E-07
148.1	61-pm-148m	1.94297E-07	1.00731E-05
152.1	61-pm-152m1	1.53623E-03	7.16823E-06
152.2	61-pm-152m2	6.41803E-04	7.22048E-06
154.1	61-pm-154m	4.31062E-03	8.78788E-06
162	61-pm-162	2.13750E+00	9.85371E-06
145	62-sm-145	2.35957E-08	6.72936E-07
146	62-sm-146	2.13252E-16	0.00000E+00
162	62-sm-162	1.31777E-01	4.04389E-06
163	62-sm-163	5.46689E-01	5.45455E-06
164	62-sm-164	5.00467E-01	4.63950E-06
165	62-sm-165	1.52824E+00	6.68757E-06
152.2	63-eu-152m2	1.20338E-04	4.31557E-07
154.1	63-eu-154m	2.51140E-04	4.98433E-07
162	63-eu-162	4.26736E-03	8.16092E-06
163	63-eu-163	9.11496E-02	4.51411E-06
164	63-eu-164	4.52239E-01	8.44305E-06
165	63-eu-165	5.11699E-01	5.71578E-06
153	64-gd-153	3.32059E-08	8.00418E-07
162	64-gd-162	1.37529E-03	2.88401E-06
163	64-gd-163	7.47167E-03	4.42006E-06
164	64-gd-164	5.32617E-04	3.21839E-06
165	64-gd-165	1.63884E-02	3.84535E-06
162	65-tb-162	1.48872E-03	5.52769E-06
163	65-tb-163	5.92433E-04	4.15883E-06
164	65-tb-164	3.85082E-03	1.10763E-05
165	65-tb-165	5.47510E-03	3.75131E-06
165	66-dy-165	8.24940E-05	1.35841E-07
165.1	66-dy-165m	9.18319E-03	1.01881E-07
166	66-dy-166	2.35957E-06	2.44514E-07
166	67-ho-166	7.18436E-06	1.38976E-07
166.1	67-ho-166m	1.83042E-11	8.16092E-06
167.1	68-er-167m	3.04012E-01	0.00000E+00

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